The Blast Furnace and Steel Plant

The Blast Furnace and Steel Plant

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Index to Contents

VOL. 7. SEPTEMBER, 1919. No. 9

Page

A. I. S. E. E. TO HOLD ANNUAL CONVENTION 417

ANDREW CARNEGIE, STEEL KING, AUTHOR, PHILANTHROPIST, ENDS REMARKABLE CAREER 419

NEW STRUCTURAL MILL AT KIUSHU STEEL WORKS 420

HEATING FURNACES AND ANNEALING FURNACES—PART IX 423
BY W. TRINKS.

MODERN STEEL METALLURGICAL CALCULATIONS—PART II 427
BY CHARLES H. F. BAGLEY.

INCREASING WET GAS WASHER EFFICIENCY 430
BY GEORGE B. CRAMP.

FOREIGN STEEL STANDARDS COMPARED TO OURS 432
BY MAJ. F. F. MACINTOSH.

PRACTICAL NOTES ON PHYSICAL TESTS OF STEEL—PART I 435
BY AUSTIN B. WILSON.

ATLAS CRUCIBLE STEEL INCREASES CAPACITY FOR MAKING AND ROLLING HIGH GRADE STEELS 438
BY H. DONALD DICKINSON.

COMPRESSED AIR OPERATED PICKLING MACHINE 442

BLUE WATER GAS AS A METALLURGICAL FUEL 443
BY A. E. BLAKE.

Page

REDUCING NON-METALLIC IMPURITIES IN STEEL 445
BY L. B. LINDEMUTH.

CHART SHOWING DEVELOPMENT OF IRON ORE INTO IRON AND STEEL..... 449
BY S. C. DICKERHOFF, JR.

OVERFIRED CAR TYPE ANNEALING FURNACE 450

BURNING PULVERIZED COAL UNDER THE BOILER 451
BY FREDERICK A. SCHEFFLER AND H. G. BARNHURST

SAFETY METHODS APPLIED TO THE BOILER ROOM 454
BY W. E. SNYDER.

HOW MUCH FUEL DOES A CLEAN BOILER SAVE 456
BY W. F. SCHAPHORST.

FOREIGN RELATIONS 458

PRODUCTION TOPICS 459

INDUSTRIAL RELATIONS 460

NEWS OF THE PLANTS 461

OPEN HEARTH 462

WITH THE EQUIPMENT MANUFACTURERS 464

SOME POINTERS ON BY-PRODUCT COKE OVEN OPERATION 465

TRADE PUBLICATIONS, TRADE NOTES... 466

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The Blast Furnace and Steel Plant

VOL. VII. PITTSBURGH, PA., SEPTEMBER, 1919. No. 9

A. I. S. E. E. To Hold Annual Convention

Thirteenth Annual Convention to Be Held in St. Louis, at the Hotel Statler, September 22 to 26—Program of Technical Papers to Be Read Forecasts Successful Meeting.

W. S. HALL.

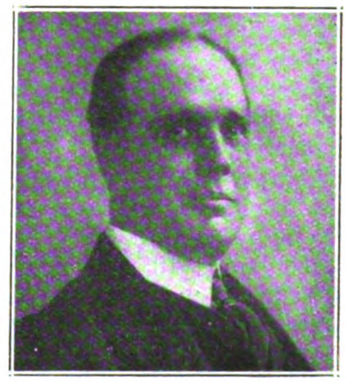
R. B. GERHARDT

A. M. BENNETT

THE Association of Iron and Steel Engineers will hold its thirteenth annual convention in St. Louis, September 22 to 26, at the Hotel Statler. The convention promises to be the largest and most successful ever held by this society.

The report of the standardization committee will be read by T. E. Tynes, that of the educational committee by A. B. Holcomb, that of the safety committee by Walter Greenwood, and Ralph D. Nye will present a report of the electric furnace committee. A joint paper covering the "Organization of the Electrical Department in the Steel Industry," will be read by C. A. Menk, T. E. Tynes, B. A. Cornwell, J. A. Morgan, J. J. Booth and R. B. Gerhardt. Mr. Tynes will deal with the storehouse method of handling spare parts in an electrical department, describing the origin of the requisitions, the ordering of the material, the checking of same when received and method of charging the material to the various departments. B. A. Cornwell will deal with the educational training of electrical employes. Mr. Cornwell urges the training of electrical employes as supported and supervised by the department superintendent in order to increase production and stimulate better workmanship. J. A. Morgan and J. J. Booth will deal with the subject of "Operation and Inspection." R. B. Gerhardt will deal with "Electrical Records and Tests in the Steel Plant," covering the subjects of operating cost records; force reports; foreman's and motor inspector's reports; station and power distribution reports; repair shop production reports; storehouse and material reports; employes records and accident reports; and generator, motor and transformer data. W. S. Hall will read a paper entitled, "Alternating Current vs. Direct Current for Table Motor Drives." This paper will consider the various items which go to make up the factors of economical operation as a whole. Good engineering practice demands that each application be considered first on its own merits and then in its relation to the general scheme as a whole. This in many cases will result in compromises which in themselves might be somewhat unsatisfactory, but in their relation to the whole may be pre-eminently satisfactory. Therefore, in choosing between the direct cur-

B. A. CORNWELL.



PAUL M. LINCOLN.

T. E. TYNES.

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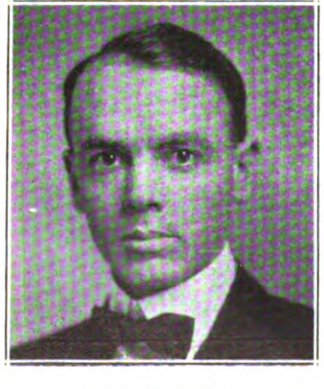
A. M. CANDY.

rent and the alternating current motor for a certain installation many items other than the operating characteristics of the two different types of motors must be considered.

J. E. Fries will read a paper entitled, "Influence of Gear Ratio on Speed of Operation, Motor Heating and Contactor Wear in Auxiliary Steel Mill Drives." This paper points out the increasing tendency to utilize smaller and smaller gear ratio in auxiliary drives such as screw down, roller tables, tilting tables, manipulators, etc. The paper proves mathematically and by data taken from actual drives that the tendency in this direction has gone too far and that there is a very definite gear ratio which will give maximum speed, minimum motor and minimum contactor troubles for each drive. It shows that there are many such drives today where motors have to be cooled by compressed air and contactors frequently renewed, and which could be made perfectly satisfactory, leaving the electrical equipment exactly as it is, by simply increasing the gear ratio. A paper entitled "Electric Heat Treatment," will be read by C. A. Winder and will describe the horizontal semi-cylindrical furnace as well as other designs such as the car type and rotary conveyor type furnace. Paul M. Lincoln will read a paper entitled "Overload Protection on Motors." A. G. Place will read a paper entitled "Overload Protection on Cranes." This paper will deal with the subject of protecting crane equipment from overloads. H. D. James will read a paper entitled, "Recent Improvements in Industrial Control." The paper describes and illustrates the operation of the well known rolling contact for magnetic contactors, analyzing the elements which have been found to be essential in a well designed contact of this type. Tests are also cited, showing the performance of this contact. The paper describes the magnetic blowout and explains the use of arc splitters to improve the performance and increase the life of magnetic contactors. A 6,600 volt airbreak magnetic contactor is described and a number of controllers which have been developed for special apparatus.

H. D. JAMES.



H. L. UNLAND

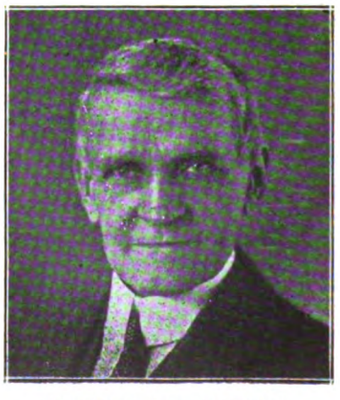
A joint paper entitled "The Present Status of Arc Welding in the Iron and Steel Industry," will be read by A. Churchward, H. L. Unland, A. M. Bennett, R. E. Kinkead, C. J. Holslag, R. M. Rush and A. M. Candy. A. Churchward will discuss the plastic arc system of welding and describe the four general fundamental types of arc welding outfits in general use at the present time.

R. E. KINKEAD.

A. M. Bennett will give a description of constant potentional and constant current types of welders with their methods of operation and control. The former of which includes systems operating at 50 volts and those in which welding is done at 30 volts with a higher volting for striking the arc. The latter describes a differentially wound variable voltage machine. R. E. Kinkead will describe the design of arc welding apparatus, the quality of welding and electric welding test cars.

C. J. Holslag covers the latest development in arc welding; namely, a special transformer delivering the arc voltage with the necessary characteristics at the terminal. R. M. Rush calls attention to the conclusions, with regard to alternating current welding arrived at by two unprejudiced authorities on welding. H. L. Unland describes the arc welding equipment of the constant potential type together with its equipment. A. M. Candy discusses arc welding apparatus designed for supplying direct current to the welding electrode, showing both the latest type of single operator portable and stationary equipment which is designed for the greatest electrical efficiency and minimum weight, where an individual source of supply is desirable for each welding operator. A brief discussion is given of alternating current arc welding bringing out its advantages and disadvantages and in concluding, a number of general welding principles are mentioned which are of paramount importance in the production of satisfactory electric arc welds as indicated by the very latest research investigations of the largest manufacturers of electrical apparatus in this country and abroad.

The program as indicated by the outline of the papers presented above indicates that a very interesting technical session will take place.



WALTER GREENWOOD

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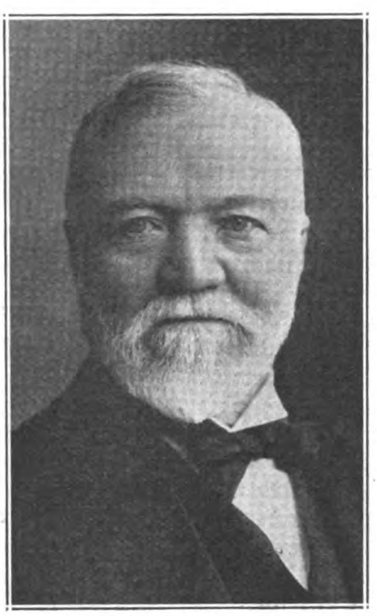
Andrew Carnegie, Steel King, Author, Philanthropist, Ends Remarkable Career.

ANDREW CARNEGIE, the world's greatest of steel makers, died suddenly and unexpectedly on Monday morning, August 11, after a brief illness with bronchial pneumonia. Mr. Carnegie was born November 25, 1837, at Dunfermline, Fifeshire, Scotland, and came to this country with his parents in 1848. For several years he was employed in various positions of minor importance.

His first connection, which seems to have started his remarkable career, was that made with the Pennsylvania Railroad under the employ of Thomas A. Scott, then superintendent. Mr. Carnegie soon rose to the position of private secretary to Mr. Scott and some time during this time made his first investment, buying 10 shares of Adams Express stock, later he invested in a sleeping car company, which investment proved to be the beginning of the Carnegie fortune.



The year 1861 marked the beginning of Mr. Carnegie's entry into the steel industry when he acted as a mediator in a partnership dispute concerning the firm of Kloman & Co., Pittsburgh. In 1864 Mr. Carnegie became financially interested in the Cyclops Iron Company, which later merged with its rival, the Kloman & Co., under the name of the Union Iron Mills. In 1870, Kloman, Carnegie & Co., organized and built the first Lucy furnace at Pittsburgh. During this period, Thomas Carnegie, Mr. Carnegie's brother, was actively interested in these enterprises. Following this, Carnegie, Phipps & Co., Ltd., also Carnegie, McCandless & Co., were organized. Following a business trip, which Mr. Carnegie took to Europe, in 1872 to sell railroad bonds, Mr. Carnegie's vision of the future of Bessemer rails, led to the final organization of the Edgar Thomson Steel Company, capitalized at $1,000,000. This company was marvelously successful. In 1883 the Homestead mills were purchased by the Carnegie interests at a time when the previous owners were unable to operate profitably. This action demonstrated one of Mr. Carnegie's principles of buying during dull times. In 1881, with Mr. Carnegie owning one-half the stock, Carnegie Brothers & Co., was organized with a capitalization of $5,000,000, including the Union Iron Mills, Lucy furnaces, Edgar Thomson Steel Company and minor properties. In 1882 H. C. Frick became associated with the Carnegie interests, from which time rapid strides were made and new organizations built, until in 1892, the Carnegie Steel Company, Ltd., was formd with a capitalization of $25,000,000, consolidating all the Carnegie properties. Mr. Carnegie's reluctance to become associated with the ore business was broken down through the insistence of Mr. Frick, which later led to the acquisition of the Oliver Iron Mining Company, and was soon followed up by the Rockefeller connections with the Carnegie Company. The latter action's unfavorable influence on the ore market led to the acquiring of millions of dollars of ore properties. In 1899, the Carnegie Steel Company with a capital stock of $100,000,000 was formed. Mr. Carnegie vigorously opposed the organization of the United States Steel Corporation, however, he sold out his entire interests to the corporation in 1901, at which time he retired.

Mr. Carnegie's benefactions founded approximately 3,000 libraries in this country and abroad. His numerous gifts and endowments reached the total of $351,165,000. The Hague Peace Palace built to carry out Mr. Carnegie's cherished dream of international peace, was erected at a cost of $1,500,000.

Mr. Carnegie contributed freely to the literature of the world, writing several books and magazine articles. In his writings, he dealt with travel, economics and philosophy. Some of the books he wrote were "Triumphant Democracy," "Advantages of Poverty," "The Gospel of Wealth," and the "Empire of Business." With regard to labor, Mr. Carnegie was strongly opposed to strikes or lockouts, saying that whether they were successful or not, they gave no direct proof as to their justice or injustice. He strongly upheld the right of the workingman to form trade unions. He was an advocate of simplified spelling, and among his chief hobbies in addition to writing, were fishing, golfing, yachting and gardening.

Mr. Carnegie attributed his success to concentration. He believed that the way to succeed is "to select some definite line of work, however small and insignificant it may appear to be, and to know more about that than anyone else knows and to let outside things alone."

Mr. Carnegie cherished the hope that his millions would be dissipated for charitable purposes before his death, which ideal, in spite of his many and numerous gifts he did not attain.

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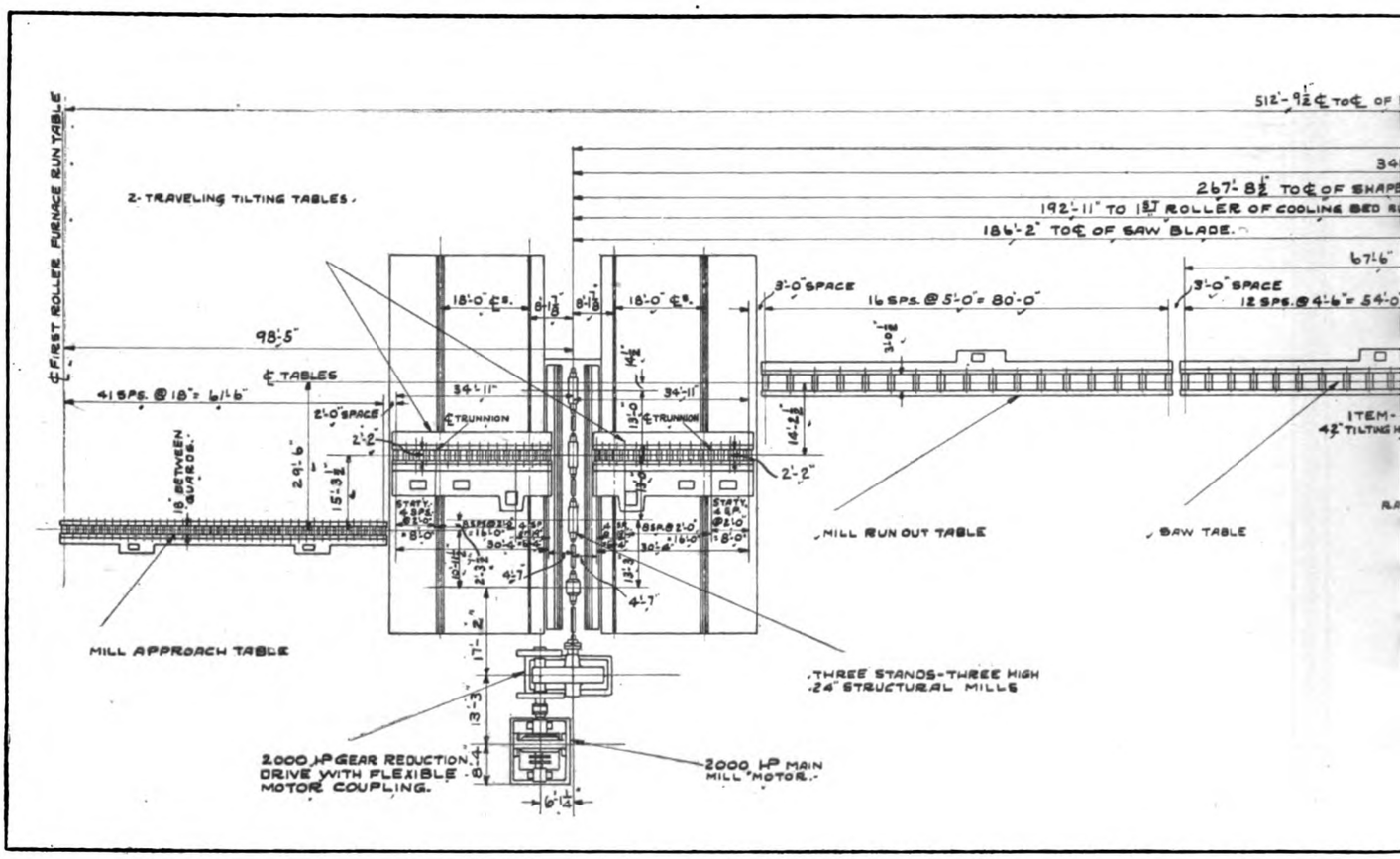

New Structural Mill Japanese Increase

THE progress of the Japanese iron and steel industry is continually being emphasized by the erection and completion of new steel plants. Iron and steel has proved itself to be the very foundation of the strength of any nation. No country realizes this more fully than Japan. Although naturally deficient in mineral resources this country has made and is making great strides in developing her iron and steel industry.

In accordance with the policy of Japan to increase her output, rapid strides are being made in completing the $3,000,000 plant of the Kiushu Steel Works at Yawata, Japan. The great majority of the equipment for this plant was bought in the United States.

The S. R. Smythe Company of Pittsburgh, drew up the plans for the Kiushu Steel Works. The plant for the present will comprise three 50-ton open hearth furnaces burning producer gas. The rolling mill plant will eventually consist of an 84 inch plate mill, a 35 inch blooming mill and a 24 inch structural mill.

The 24 inch three-high structural mill was designed and built by the Mackintosh, Hemphill & Co., Pittsburgh, Pa., and is of their standard massive construction throughout. It is the present plan to roll the finished product direct from cast ingots until the 35 inch blooming mill is installed. Then the structural mill will roll from rolled blooms. The ingots at present are dumped onto the approach table and are conveyed to the mill by means of traveling tilting tables. From the mill the ingots pass to the saw to the rolling bed after which they pass through the straightener to the shear and finishing end. The traveling tilting tables as well as the shear, which were built by Mackintosh, Hemphill & Co., are shown in the accompanying illustrations.

The principle sizes and dimensions of the structural mill will be found in the general layout shown above.

The tilting tables are of the low type, heavy construction, and are motor driven throughout. The mill is a standard three-high, three stand, structural mill with cut pinions totally enclosed, running in oil, driven by a 2,000 hp, General Electric motor through a gear reduction drive. Two flywheels are mounted on the high speed shaft of this drive. The connection between the motor and the gear drive is by means of a flexible coupling.

The hot saw is of the tilting type, 42 inches diameter blade, motor driven. The cooling bed is of the rope transfer type, having two sets of ropes, one set carrying a carriage with dogs, the other set carrying a straightening transfer bar. The bed is 67′ 6″ long by 36′ 0″ wide, and is designed so that it can be operated in two sections or as one complete unit at the will of the operator. Provision has been made in the layout that the length of this bed can be doubled by moving the hot saw toward the mill, should the

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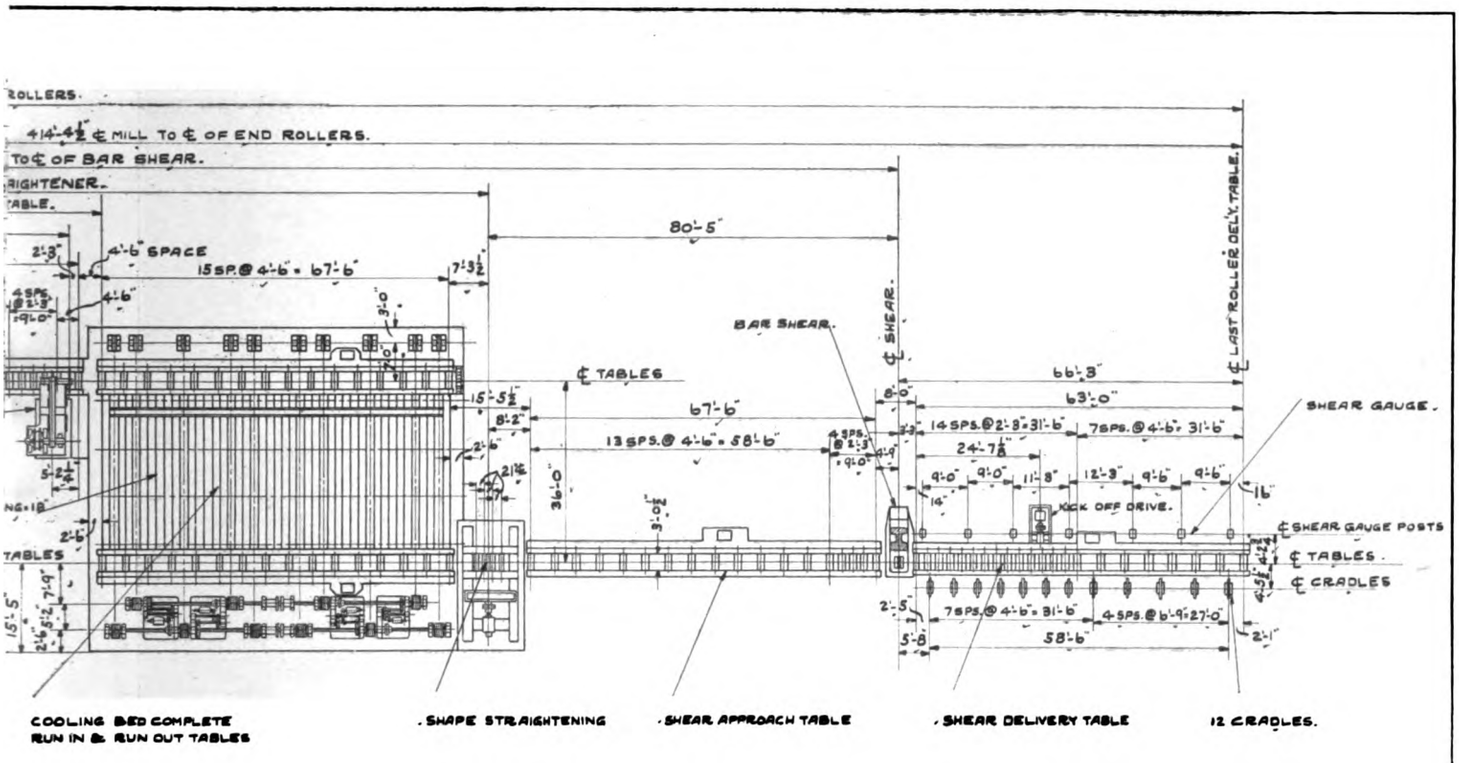


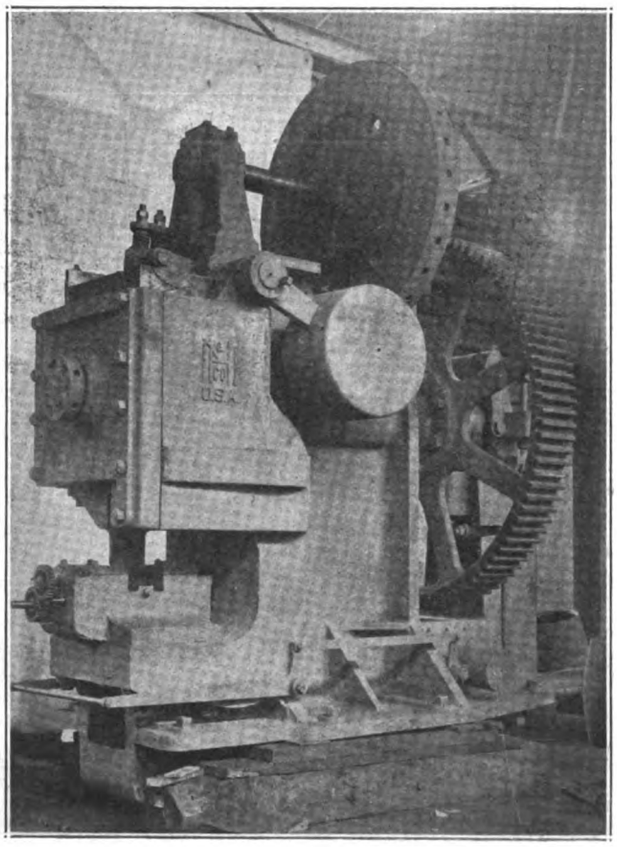
at Kiushu Steel Works Steel Productian

tonnage requirements ever make it necessary to do so. The straightening machine is motor operated throughout, of the eight roll type, designed to straighten all kinds of structural shapes.

The shear is of Mackintosh, Hemphill & Co., standard design for cutting structural shapes and bars, and is of ample capacity to handle the product of this mill. After being sheared the product is run on to the shear run out table where it is automatically kicked off onto cradles and from there taken to the finishing floors.

In addition to the structural mill the 84 inch plate mill and auxiliaries is being built by the Morgan Engineering Company, Alliance, O. The top and bottom rolls of the mill are 30 inches diameter and the middle roll is 18 inches in diameter. The cranes are being furnished by the Alliance Machine Company, Alliance, O., and the ladles by the Treadwell Construction Company, Midland, Pa.

The plate and structural mills are served by four door, side charging heating furnaces, fuel for which is drawn from Smythe gas producers. The charging machines for the furnaces are furnished by the Wellman-Seaver-Morgan Company, Cleveland.



Shear for cutting structural shapes and bars.

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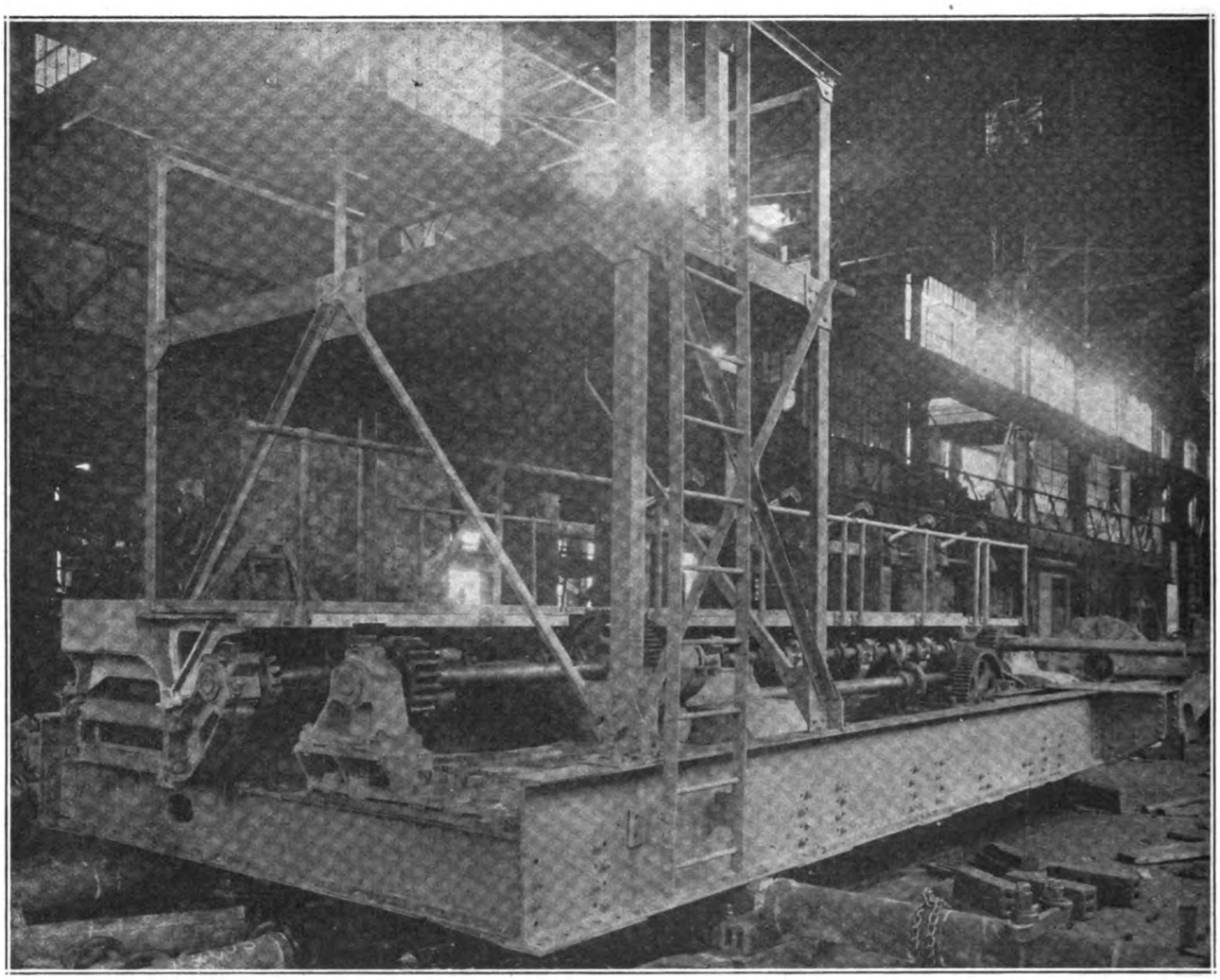

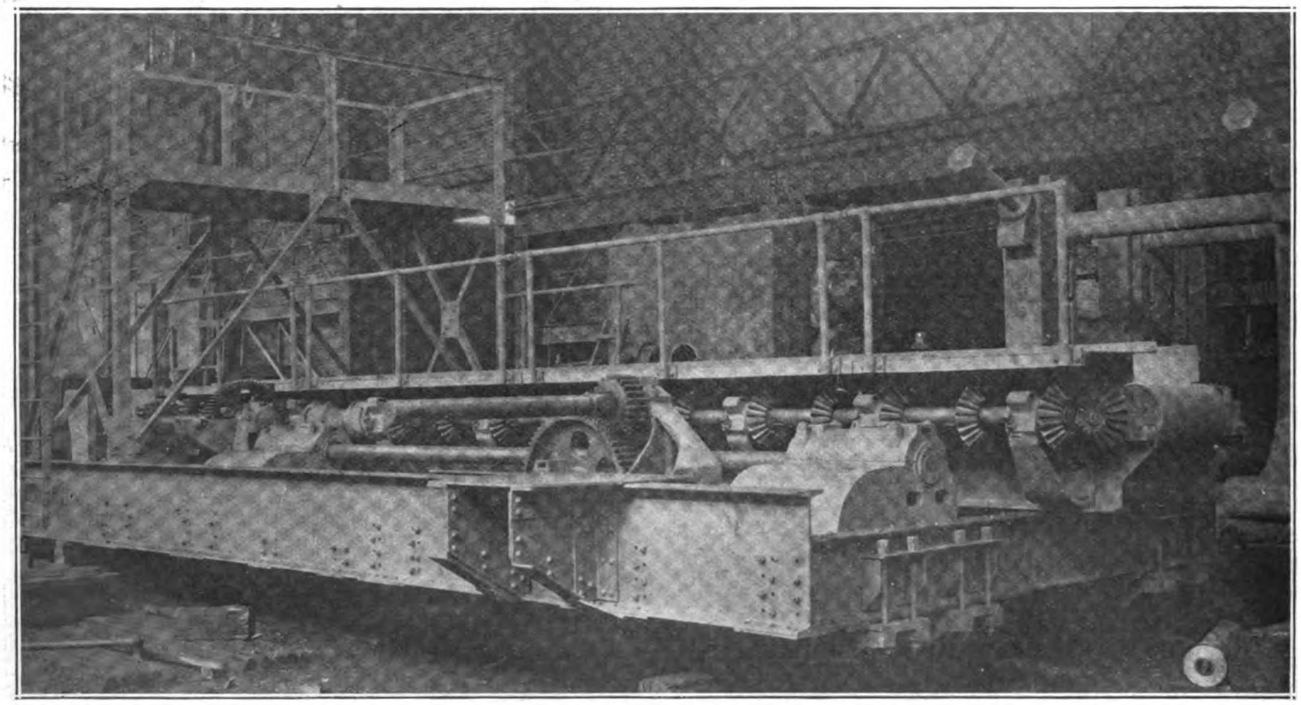

Two views of the tilting tables serving the 24″ structural mill and built for the Kiushu Steel Works by Mackintosh, Hemphill & Co., Pittsburgh, Pa. The tilting tables are of the low type, heavy construction and are motor driven.

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Heating Furnaces and Annealing Furnaces

Computing Boiler Horsepower Available from Waste Heat of Furnace—Heating Surface of Waste Heat Boilers Required for Different Conditions—Conditions Necessary for Profitable Installation.

By W. TRINKS.

PART IX.

In part VI of this series the use of the waste heat of the flue gases for the generation of steam was mentioned as one of the common methods of increasing the fuel economy of furnaces.

In some plants waste heat boilers have been used successfully, while in others they were tried out, were found wanting, and were either taken out or were converted into direct fired boilers. From the number of failures it is quite evident that many factors must come together to make a waste heat boiler successful. Although much has been said and written about waste heat boilers, the problem of their proper use remains apparently unsolved with a very large number of furnace engineers.

The subject will be discussed under three headings, first, amount of steam which can be generated from a given furnace, second, size of boiler necessary to generate this steam, and third, plant conditions which must exist and precautions in design and operation which must be observed to make the installation of a waste heat boiler advisable.

Turning to the first item, namely the heat which can be generated from a given furnace, we realize that the quantity of waste heat depends upon the temperature of the flue gases leaving the furnaces, upon the weight of these flue gases, and upon the temperature to which these flue gases can be cooled down. The temperature of the furnace flue gases is determined by the temperature of the furnace, unless regenerators or recuperators are used. And the use of these last two heat economizers will be excluded from the present discussion, because, if properly designed, they cool the flue gases of heating and annealing furnaces to such an extent that the installation of waste heat boilers becomes inadvisable.

The quantity of flue gas depends upon the heat

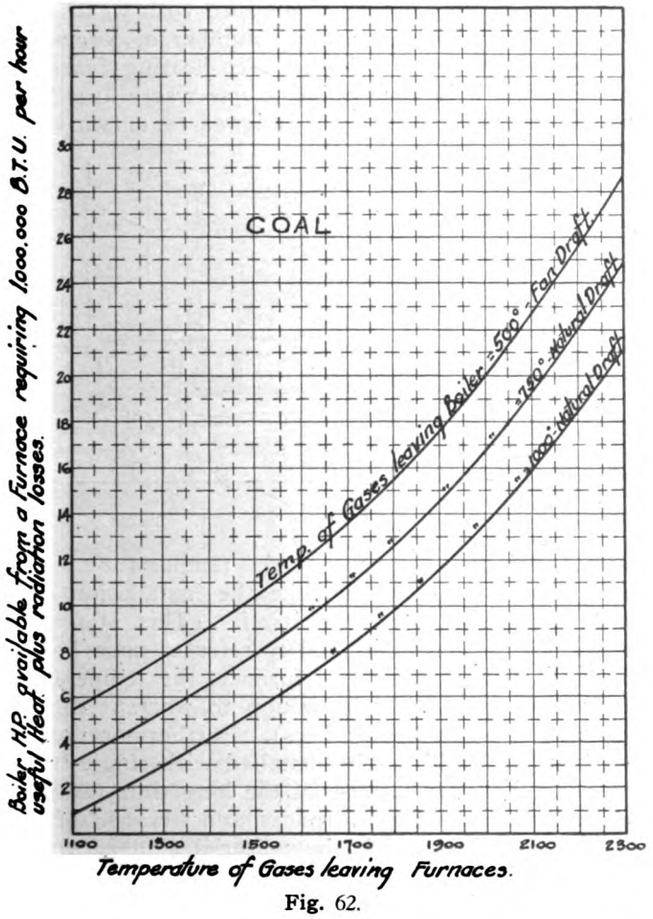

Fig. 62.

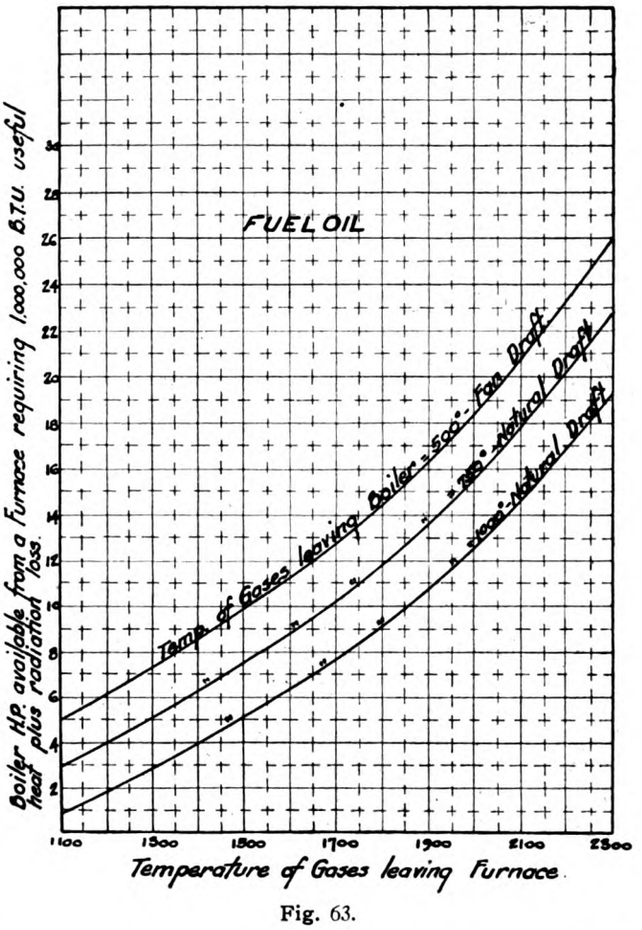

Fig. 63.

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requirement of the furnace and can be found as indicated in part IV of this series. The temperature of the flue gases leaving the waste heat boilers depends upon the size of the waste heat boilers and the available draft. For the purpose of bringing order into this bewildering chaos of valuables, the curves of Fig. 62 and 63 were drawn. In these curves the abcissae represent furnace temperatures, while the ordinates represent boiler horsepower available from the flue gases of a furnace which requires 1,000,000 Btu per hour for heating, radiation, and convection, and in which the flue gases leave at furnace temperature with 5 per cent excess air. Several stack temperatures were assumed. A stack temperature of 500 degrees F. is always attainable with fan draft, while 750 degrees F. should be easily attainable with natural draft. A stack temperature of 1,000 degrees F. should never occur with waste heat boilers, but it was plotted for the sake of completeness. Fig. 62 holds for coal whereas Fig. 63 was drawn for fuel oil. It will be noted that the difference between the boiler horsepowers resulting from the two fuels is very small.

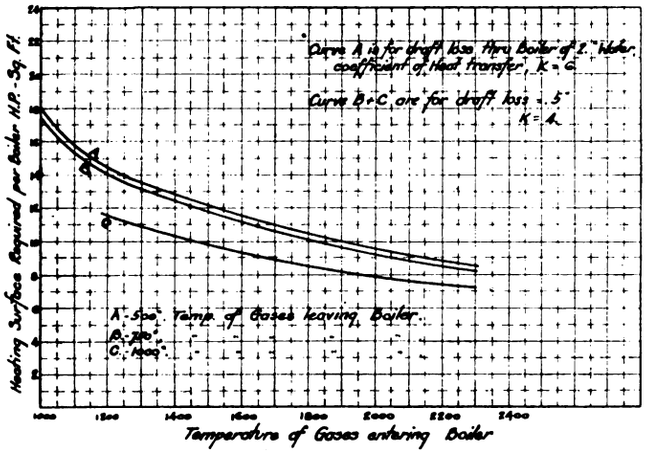

Fig. 64

The curves are based on "all" of the flue gases reaching the boiler of "furnace temperature." In practice neither of the two emphasized conditions are realized. The result is that in practice the available horsepower is only a fraction of that indicated by the curves; values of the coefficient will be given later on.

The second item to be discussed in this installment is the heating surface per boiler horsepower. It will be remembered that with coal fired water tube boilers an arbitrary value of 10 square feet of heating surface has been adopted. It will also be remembered that the heating surface per boiler horsepower depends upon the temperature of the incoming flue gases, upon the temperature of the outgoing flue gases, and upon the method of baffling. Again there are so many variables affecting the required value for the heating surface that it appeared wise to compute these values for given average conditions and to plot them in the shape of curves, see Fig. 64. Just as before, a temperature of the flue gases of 500 degrees F. was assumed for fan draft, while 750 degrees F. and 1,000 degrees F. were taken for natural draft. It will be noticed that two of the curves lie very close together. This is due to the fact that with fan draft close baffling is used, while with natural draft a more open baffling is necessary. The draft loss through the boiler for the two cases is 2 inches of water and ½ inch of water respectively. The methods of so designing the baffling that either one of these pressure drops is attained belongs in steam boiler design and not in a treatise on furnaces. To use the curves, find the available horsepower from Fig. 62 or Fig. 63 and multiply by the square foot per boiler horsepower from Fig. 64.

The third and probably the most important item is the question of what plant conditions must exist to make the installation of a waste heat boiler advisable, and what precautions in design and operation must be observed to make the installation successful. This question can be answered step by step by stating under what conditions waste heat boilers should not be installed. First, it is quite evident that all of those furnaces which discharge all of their flue gases through the door cannot be equipped with waste heat boilers. This excludes a large number of forge furnaces, bolt heading furnaces, rivet heating furnaces, etc. Second, it is inadvisable to use waste heat boilers in connection with well designed regenerative or

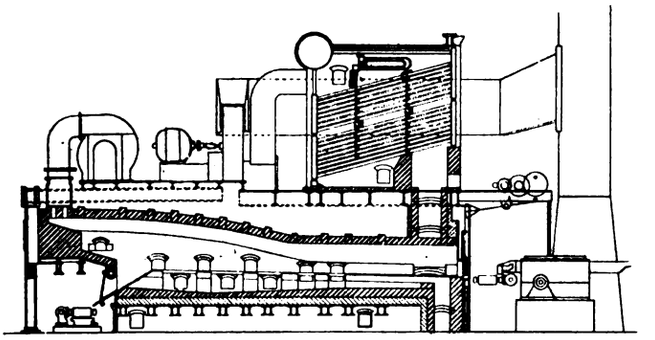

Fig. 65.

recuperative furnaces because the temperature of the flue gases is too low to make the installation of a waste heat boiler pay for itself. (This statement should not be misunderstood to refer to open hearth furnaces; with that type of furnace, the temperature of the flue gases is high enough to warrant the installation of waste heat boilers). Furthermore, waste heat boilers should not be installed with single batch annealing furnaces because of the long time which is required to heat these furnaces and because of the long time during which the material cools down in the furnace. It is also doubtful whether waste heat boilers are advisable in connection with well designed continuous furnaces, for although the flue gases leave the furnace proper at almost 1,100 degrees F. they can be cooled down to about 700 degrees F. in a metallic recuperator. These restrictions limit the use of waste heat boilers to a comparatively small number of heating furnaces, namely to those in which neither the continuous principle nor the regenerative principle is applied or can be applied. With that, we land at the coal-fired heating furnace for heavy pieces, such as forge furnaces and mill furnaces for heavy

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stock. By "coal-fired" is meant the method of burning coal on a grate or else of burning powdered coal, if the latter be accomplished without regeneration. In this type of furnace waste heat boilers or preheating pits utilizing waste heat from the furnaces are the only two methods of economizing in fuel.

It is true that waste heat boilers have been used in connection with other furnaces, such as continuous furnaces, or open door forge furnaces for small material. Examples of such furnaces have been published. See for instance, the paper by A. D. Pratt before the American Society of Mechanical Engineers, December, 1916, Fig. 7 of which paper is reproduced as Fig. 65. In this furnace the gases enter the boiler at a temperature which at times is as high as 1,745 degrees F. This temperature would be decidedly too high for good economy, if the furnace were to work as a continuous furnace without a waste heat boiler. To obtain better economy the output of the

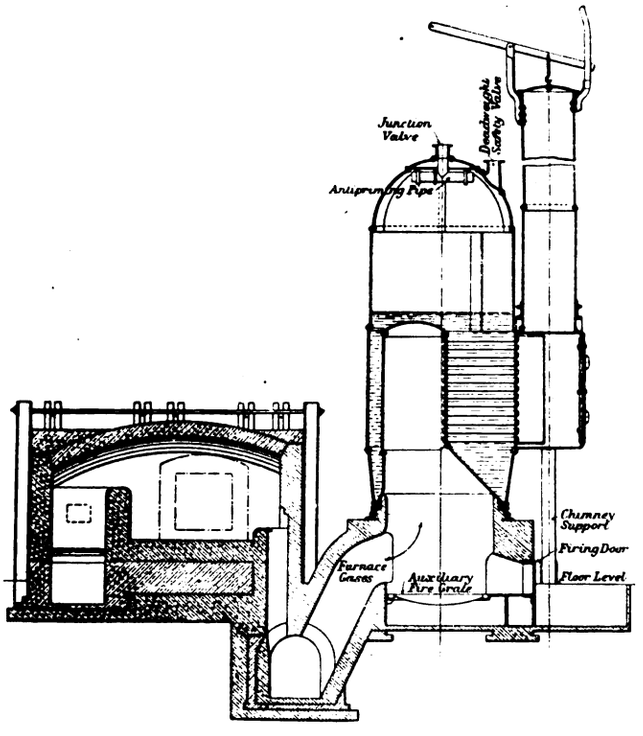

Fig. 66.

furnace must be decreased or the length of the furnace must be increased. But the latter is not desirable for the heavy stock handled by this furnace (which feature will be taken up separately later on under the heading of continuous furnaces). This is probably the reason why, in the case in question, a waste heat boiler was installed in connection with a continuous furnace, contrary to usual practice.

Another exception to the limitations placed upon the range of applicability of the waste heat boiler is found in the *Iron Age*, page 45, January, 1915. The installation in question consists of the combination of two open slot forge furnaces with a vertical waste heat boiler. With a furnace of that description, the tendency of the heaters is to have a very large part of the flame come out through the slots, leaving but little for the flues to take care of. For this reason its operation requires considerable vigilance on the part of the steam engineering department to insure steady and sufficient flow of hot flue gas to the waste boiler.

Turning now to the principal and legitimate field of the waste heat boiler namely, that of the coal-fired forge furnace, mill furnace for heavy stock, and puddling furnace, we find that several precautions must be observed in the design and in the operation of the combined furnace and boiler plant to make its operation a success. The furnace doors must be so designed and maintained that they are reasonably tight, for this reason: In practically all coal-fired furnaces air is blown into the ash pit by means of steam jets. The pressure in the ash pit is sufficient to maintain a slight pressure in the heating chamber of the furnace, say between 1/40 and 1/30 of an inch of water. This, of course, is done to keep air from entering the furnace and oxidizing the steel. If the doors are a poor fit, or broken, or partly open, a very large quantity of flue gas will be discharged into the mill building. Roughly, for each square foot of leakage area, the gases of combustion of 100 pounds of coal escape, from which figure it will be readily seen that a leaky furnace structure, pressure in the heating chamber, and a waste heat boiler will not work together. Furthermore, heaters must be instructed to keep the doors well closed, or if they must be open on account of large ingots sticking out through the door, to brick up and mud up the remaining openings with great care.

The flue leading from the furnace to the boiler should be just as short and direct as possible. If the flue is made long, one of two things will happen. Either the flue is made of large cross section, which

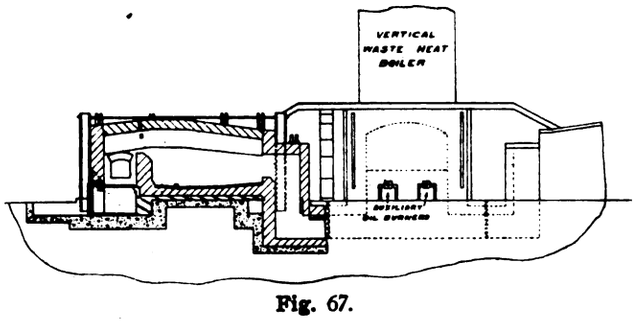

Fig. 67.

means a great temperature drop of flue gases between the furnace and the boiler, or else the flue is made of small cross section, which means considerable pressure drop or draft loss in the furnace and boiler and favors infiltration of cold air. It also renders difficult the starting of the boiler unless the latter be equipped with a separate heating device, such as an auxiliary grate or an oil or gas burner.

Infiltration of cold air is perhaps the greatest enemy of the waste heat boiler. In Europe it is to a large extent overcome by the use of internal fired boilers, see Figs. 66 and 68, the first of which is an English installation, and the second of which is a German installation. In the United States water tube boilers are used almost exclusively and with them the difficulty of keeping the setting tight is always pres-

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ent.* The best remedy against this condition is to enclose the boiler setting with a sheet steel casing about ⅛ inch in thickness. These facts explain the statements made in the early part of the installment that only a fraction of the ideal horsepower can actually be realized in a waste heat boiler. That fraction depends principally upon the leakage of hot gases and flame from the furnace door, upon the infiltration of cold air through the flues and through the boiler setting and upon heat losses from the flue between furnace and boilers. The fraction may be as low as 10 per cent and may be as high as 90 per cent, with an average of 70 per cent.

It is very desirable to equip the waste heat boiler with a damper, which damper should be on the low temperature side of the boiler. See Fig 66. By means of the damper the pressure in the furnace can be regulated to furnish the small amount of pressure desired. It is also advisable to install a damper between the furnace and the boiler, but this damper must never be used as such. It must be used either in the wide open or the dead shut position. This damper is absolutely necessary if several furnaces discharge their flue gases into one common waste heat boiler, because one or more of the furnaces may be off for repairs.

In some European countries, there exist laws which provide for the installation of a short circuit from the furnace to the stack, so that in case of accident to the boilers the gases can be short circuited directly from the furnaces to the stack. Since this passage is to be used in an emergency only, it can regularly be closed by a thin brick wall which, in case of necessity can be battered down through a small hole in the wall of the flue. The safety short circuit is very seldom found in American installations, although it insures absolutely uninterrupted furnace operation in case of accident to the boiler. The reason for the absence of this short circuit probably lies in the fact that, in most installations, continued operation of the furnace is impossible anyway after a boiler accident, because there is no steam to operate the hammer, press, or engine.

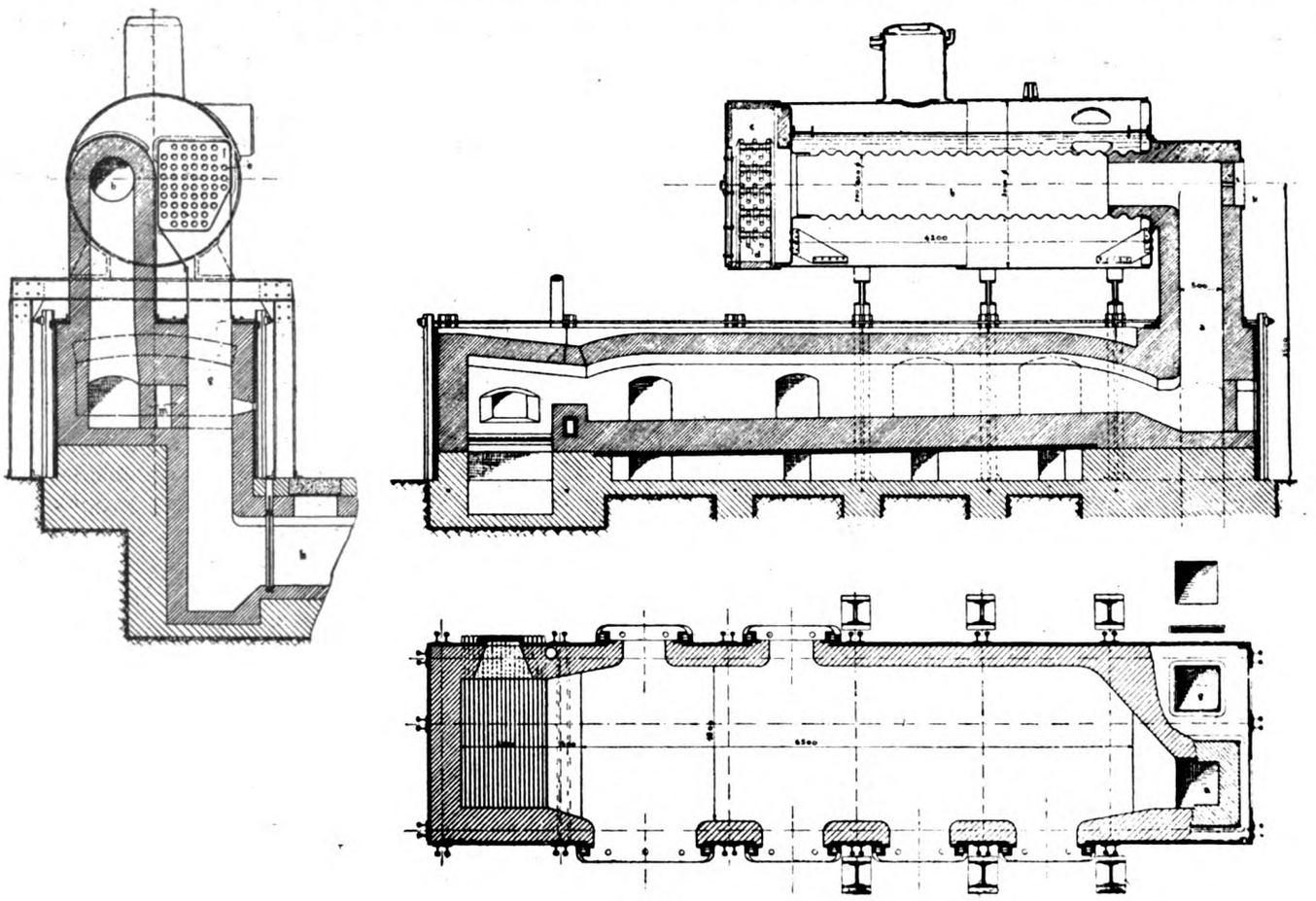

Fig. 68.

Fig. 67 shows a combination of two forge furnaces and a waste heat boiler which is very popular in forge plants.†

*This statement should not be taken to exclude the other type. Water tube boilers have been used in Europe for waste heat purposes, while some internally fired boilers, particularly of the locomotive type, have been used for that purpose in the United States.

†This illustration was furnished by the courtesy of Tate, Jones & Co., furnace engineers, Pittsburgh, Pa. It shows an installation made by them. Although the forge furnaces are coal-fired, oil firing is used as the auxiliary source of heat for the boiler, which arrangement assists materially in preventing the infiltration of cold air.

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Although this type of installation is a very popular one, the writer knows of one large forge plant in which the waste heat boilers are being removed one by one and in which steam is being generated for the presses in a separate boiler plant equipped with a few large units. The reason for the giving up of the waste heat boilers and for the burning of additional coal in a separate boiler plant lies in the large amount of labor which the waste heat boilers require on account of their scattered location throughout the plant. All of which teaches that the waste heat boiler is particularly well applicable in plants where only one waste heat boiler is used or where several waste heat boilers can be located close together, where the steam is to be used very close to the spot where it is generated and is used for the purpose of working up the steel from the waste heat of which it was produced.

Although coal-fired furnaces form the most fruitful field for waste heat boilers, there are other furnaces which may profitably be equipped with waste heat boilers under conditions favorable to the latter. Such conditions are found in the absence or inadvisability of regenerators or of other fuel economizing devices, in the grouping of several furnaces close together in such a manner that a large waste heat boiler can be installed with short, well insulated, flues and yet is out of the way of the crane, and in the demand for steam close to the furnaces.

Modern Steel Metallurgical Calculations

Bessemer Acid Process—Bessemer Basic Process—Basic Open Hearth Process With Direct Molten Metal—Cold Pig and Scrap in Hot Metal Open Hearth Basic Practice.

By CHARLES H. F. BAGLEY.

PART II.

Bessemer Acid Process, With Molten Hematite Iron (Mixed Nos.).

Oxidation Table—If the steel when blown is to contain 0.20 per cent carbon; silicon, trace; manganese, trace, there will be oxidized per 100 tons of metal charged as shown in Table 1.

Blast—Taking normal air at 10 degrees C and 750 mm pressure, under which conditions it will contain approximately 0.290 tons of oxygen per 1,000 cubic meters, and assuming all carbon burnt to CO and no free oxygen to pass through unconsumed—there will be required not less than 10 (7.95 ÷ 0.290) = 274 cubic meters of free air per ton of iron.

Slag—If the slag is to contain 65 per cent acids (SiO_2), the total slag make will be 5.36 ÷ 0.65 = 8.25 tons; made up approximately as under:

		Per Cent.
SiO_2	5.36 tons	= 65.0
MnO	1.29 tons	= 15.6
FeO	1.60 tons	= 19.4 (Fe = 1.24 tons)
Total	8.25 tons	=100.0

Yield—The metallic losses and balance sheet are approximately as under:

Dr. Metallic charge	100.00	Cr. Metalloids oxidized	7.10
Ferro alloys (say)	0.70	Fe (as oxide) in slag	1.24
		Mechanical losses } Volatilized } (say)	6.00
		Yield—ingots and scrap	86.36
Total	100.70	Total	100.70

N.B.—It is well known that in the early and cooler stages of the blow CO_2 is largely produced, and that it falls off later as the temperature rises—probably due to a portion of the blast passing through the metal unconsumed and burning the CO to CO_2 above the surface of the metal. Correspondingly more blast is required than as calculated for CO, as above, but it is easily supplied, and does not affect the calculations in any other way.

From paper read before British Iron and Steel Institute.

Bessemer Basic Process With Molten "Thomas" Iron

Oxidation Table—If the steel when blown is to contain 0.20 per cent carbon, 0.05 phosphorus, and 0.20 manganese, there will be oxidized per 100 tons of metal charged as shown in Table 2.

Blast—Taking normal air, assumed dry, at 0.290 tons of oxygen per 1,000 cubic meters—as before—there will be required not less than 10 (7.99 ÷ 0.290) = 276 cubic meters of free air per ton of iron.

Slag—If the slag is to contain 28 per cent acids ($SiO_2 + P_2O_5$), the slag make will be approximately 6.11 ÷ 0.28 = 21.82 tons of slag, to make which there is required burnt lime (at 96.0 per cent CaO in lime and 50 per cent CaO in slag) = 11.3 tons. The composition of the slag will be approximately:

		Per Cent.
SiO_2	1.07 tons	= 4.9
P_2O_5	5.04 tons	= 23.1
MnO	2.58 tons	= 11.8
CaO	10.91 tons	= 50.0
MgO	0.87 tons	= 4.0
Al_2O_3	... tons	= ..
FeO	1.35 tons	= 6.2 (Fe = 1.05 tons)
Totals	21.82 tons	=100.0

Yield—The metallic losses and balance sheet are approximately as under:

Dr. Metallic charge	100.00	Cr. Metalloids oxidized	7.70
Ferro alloys (say)	0.70	Fe (as oxide) in slag	1.05
		Mechanical losses } Volatilized } (say)	6.00
		Yield—ingots and scrap	85.95
Total	100.70	Total	100.70

Basic Open-Hearth (Talbot) Process With Direct Molten Metal—Common Forge Iron.

Oxidation Table—If the steel before tapping is to

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contain 0.20 per cent carbon, 0.05 phosphorus, and 0.10 manganese, there will be oxidized per 100 tons of metal charged as shown in Table IV.

Oxides—If supplied as Fe_2O_3, this oxygen would represent 8.54 ÷ 0.30 = 28.5 tons Fe_2O_3; or of ore containing 65 per cent. Fe (70 ÷ 65 × 28.5) = 30.8 tons of ore, introducing 20.0 tons of Fe; and also SiO_2 (at 3.0 per cent) = 0.03 × 30.8 = 0.92 tons.

Slag Make, Lime, etc.—The total acids present now are:

SiO_2 from the iron.....	3.86	
SiO_2 from the ore.....	0.92	= 5.08 tons SiO_2
SiO_2 from the lime (say)..	0.30	
P_2O_5 from the iron.....	3.44	
Total	8.52	

As the slag is to contain 28 per cent acids and 48 per cent CaO, the total slag make will be 8.52 ÷ 0.28 = 30.4 tons; and the burnt lime required (at 96 per cent CaO) will be exactly half = 15.2 tons.

Slag Analysis—The composition of the slag will be approximately as under:

SiO_2	5.08 tons =	16.7
P_2O_5	3.44 tons =	11.3
MnO	0.64 tons =	2.2
CaO	.... at	48.0
MgO	.... at	5.0
Al_2O_3, etc.	.... at	2.0
FeO	4.50 tons =	14.8 (= 3.50 tons Fe)
Totals	30.4 tons =	100.0

The metallic balance sheet will be approximately as under:

Dr. Metallic charge.	100.00	Cr. Metalloids oxidized...	7.10
Fe from ore.....	20.00	Fe (as oxide) in slag...	3.50
Ferro alloys (say)	0.70	Mechanical losses } Volatilized } (say)	4.00
		Yield—ingots and scrap.	106.10
Total	120.70	Total	120.70

dized in heating up the cold pig or scrap. To avoid chilling the molten metal all cold pig and scrap, together with most of the lime and oxides required, should be charged first and well heated before the metal is poured in. How far this heating should be carried is a matter of judgment; for if not hot enough the metal will chill—or even set—on the bottem and round the cold stock, and a long time will be spent in getting heat to "lift" it before a "clear" boil will set in. On the other hand, if overheated—say to the point of incipient fusion—and heavily oxidized, a violent reaction immediately occurs with the molten iron, and the furnace boils over; the half-spent slag, laden with excess oxide, etc., pouring out of the slag notches and doors to waste. This is the principle of the "Monell" process. Such reactions do the furnace no good, and a heavy foaming slag is usually left which takes some time to "clear." There may not then be enough of it left to do the work, and fresh additions of lime and oxides (cold) are needed to make good the loss and complete the process. Considerable loss of time and output as well as of materials results. A mean should therefore be aimed at between these limiting conditions—just short of getting such reactions—at which neither the molten metal is chilled, nor the slag lost as above, and a "clear boil" obtained in the minimum of time without loss of heat or of material. With a little experience on a given furnace, a rule can be laid down stipulating a definite time allowance (say two hours) for heating the scrap, etc., before the metal is charged.

The calculations and results are similar to those for ordinary cold pig and scrap charges of similar proportion (due allowance being made for the absence of sand), provided no slag be lost by such reactions. If a refining mixer plant is attached to the basic open-hearth steel department, it may be used within its

Table 1.

		Tons		Tons		Tons	
Carbon from	3.80 to 0.20	= 3.60	requiring oxygen	4.80,	producing	8.40	CO gas
Silicon from	2.50 to ...	= 2.50	requiring oxygen	0.57,	producing	1.07	SiO_2
Manganese from	1.00 to ...	= 1.00	requiring oxygen	0.29,	producing	1.29	MnO
Totals		7.10		7.95		6.65	solids

Table 2.

		Tons		Tons		Tons	
Carbon from	3.20 to 0.20	= 3.00	requiring oxygen	4.00,	producing	7.00	CO gas
Silicon from	0.50 to ...	= 0.50	requiring oxygen	0.57,	producing	1.07	SiO_2
Phosphorus from	2.25 to 0.05	= 2.20	requiring oxygen	2.84,	producing	5.04	P_2O_5
Manganese from	2.20 to 0.20	= 2.00	requiring oxygen	0.58,	producing	2.58	MnO
Totals		7.70		7.99		8.69	solids

Cold Pig and Scrap in Hot Metal Open-Hearth Basic Practice.

A proportion of cold steel scrap—up to 50 per cent—may sometimes be worked to advantage in direct hot metal practice, especially with a common iron, and has the effect of diluting the impurities of the iron and so reducing the consumption of lime and the make of slag in similar proportion. The oxides consumption and the metallic yield will fall in heavier proportion, owing to the large amount of metal oxi-

heating capacity for melting steel scrap; and the metal will be improved for the steel furnaces in being diluted with nearly pure iron, in which the chief metalloid is manganese. Steel scrap has, of course, no direct oxidizing effect on the molten iron, but will reduce its carbon, silicon, and phosphorus contents by dilution; its effect on the manganese depending on the percentage of manganese it contains. However, both silicon and manganese are subject to oxidization in the refining process. Scrap melting, however, re-

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Table 3.

Bessemer Process. Tabulated Results per 100 Tons of Iron Charged.

Pig Iron Used.	Acid Proces. Hem. M. Nos.	Acid Proces. Spec. Hem.	Basic Process Com. Forge.	Basic Process "Thomas."
Oxygen required (tons)	7.95	5.31	8.54	7.99
Equivalent air per ton	270 M^3	183 M^3	294 M^3	276 M^3
Total products to slag	6.65	3.01	7.94	8.69
Total acids	5.36	2.14	7.30	6.11
Slag make at 65 per cent SiO_2	8.25	3.30	...	...
Slag make at 28 per cent acids	...	...	26.0	21.8
Burnt lime (for 50 per cent CaO)	...	...	13.5	11.3
Slag Analysis: SiO_2	5.36 = 65.0	2.14 = 65.0	3.86 = 14.8	1.07 = 4.9
P_2O_5	..	..	3.44 = 13.2	5.04 = 23.1
MnO	1.29 = 15.6	0.87 = 26.4	0.64 = 2.5	2.58 = 11.8
CaO	..	..	at 50.0	at 50.0
MgO	..	..	at 4.0	at 4.0
Al_2O_3	..	..	..	..
FeO	1.60 = 19.4	0.29 = 8.6	4.03 = 15.5	1.35 = 6.2
Totals	8.25 =100.0	3.30 =100.0	26.00 =100.0	21.82= 100.0
Metallic Balance Sheet:				
Dr. Metallic charges	100.00	100.00	100.00	100.00
Ferro alloys (say)	0.70	0.70	0.70	0.70
Totals	100.70	100.70	100.70	100.70
Cr. Metalloids oxidized	7.10	4.60	7.10	7.70
Fe (as oxide) in slag	1.24	0.22	2.92	1.05
Mechanical losses (say)	6.00	6.00	6.00	6.00
Volatilized (say)	86.36	89.88	84.68	85.95
Yield—ingots and scrap				
Totals	100.70	100.70	100.70	100.70

N. B.—MnO being more volatile than FeO will usually be lower than as calculated above—its place being taken by FeO, with consequent slight increase in Fe loss (as oxide) in the slag.

Table 4.

	Tons		Tons		Tons	
Carbon from	3.50 to 0.20 = 3.30	requiring oxygen	4.40,	producing	7.70	CO gas
Silicon from	1.80 to ... = 1.80	requiring oxygen	2.06,	producing	3.86	SiO_2
Phosphorus from	1.55 to 0.05 = 1.50	requiring oxygen	1.94,	producing	3.44	P_2O_5
Manganese from	0.60 to 0.10 = 0.50	requiring oxygen	0.14,	producing	0.64	MnO
Totals	7.10		8.54		7.94	solids

Table 5.

Basic Open-Hearth (Talbot) Hot Metal Process. Tabulated Results per 100 Tons of Pig Iron.

Pig Iron Used.	1. Hem. (M. Nos.).	2. Hem. (Spec.)	3. Com. Forge.	4. Com. Basic.	5. "Thomas."
Metalloids oxidized (tons)	7.10	4.60	7.10	6.20	7.70
Oxygen required	7.95	5.31	8.54	6.98	7.99
Equivalent Fe_2O_3 at 70 per cent Fe	26.2	17.6	28.5	23.3	26.7
Equivalent ore at 65 per cent Fe	28.2	19.1	30.8	25.1	28.8
Fe introduced	18.3	12.3	20.0	16.3	18.7
SiO_2 introduced at 3 per cent of ore	0.84	0.58	0.92	0.75	0.86
Acids: SiO_2 from metal	5.36	2.14	3.86	2.14	1.07
SiO_2 from oxides	0.84	0.58	0.92	0.75	0.86
SiO_2 from lime	0.22	0.10	0.30	0.21	0.26
P_2O_5 from metal	...	...	3.44	2.75	5.04
Total acids	6.42	2.82	8.52	5.85	7.23
Slag make (at 28 per cent acids)	22.92	10.1	30.4	20.9	25.9
Lime required (for 48 per cent CaO)	11.5	5.0	15.2	10.5	13.0
Slag Analysis: SiO_2	6.42 = 28.0	2.82 = 28.0	5.08 = 16.7	3.10 = 14.8	2.19 = 8.4
P_2O_5	... ...	... ...	3.44 = 11.3	2.75 = 13.2	5.04 = 19.5
MnO	1.29 = 5.6	0.87 = 8.6	0.64 = 2.2	1.29 = 6.2	2.58 = 10.0
CaO	at 48.0	at 48.0	at 48.0	at 48.0	at 48.0
MgO	at 5.0	at 5.0	at 5.0	at 5.0	at 5.0
Al_2O_3	at 2.0	at 2.0	at 2.0	at 2.0	at 2.0
FeO	2.61 = 11.4	0.85 = 8.4	4.52 = 14.8	2.26 = 10.8	1.81 = 7.0
Totals	22.9 =100.0	10.1 =100.0	30.4 =100.0	0.9 =100.0	25.9 =100.0
Metallic Balance Sheet:					
Dr. Metallic charge	100.00	100.00	100.00	100.00	100.00
Fe from ore	18.30	12.30	20.00	16.30	18.70
Ferro alloys (say)	0.70	0.70	0.70	0.70	0.70
Totals	119.00	113.00	120.70	117.00	119.40
Cr. Metalloids oxidized	7.10	4.60	7.10	6.20	7.70
Fe (as oxide) in slag	2.03	0.66	3.50	1.76	1.41
Mechanical losses Volatilized (say)	4.00	4.00	4.00	4.00	4.00
Yield—ingots and scrap	106.57	103.74	106.10	105.04	106.29
Totals	119.00	113.00	120.70	117.00	119.40

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quires heat, and can only be done at the expense of refining, unless the mixer has capacity to spare.

Cold Pig Iron and Scrap Processes.

Where cold pig iron and scrap are to be used, account should be taken of

1. The average analysis of the mixture.
2. The sand coating—if any—on the pig iron.
3. The oxidation of the charge in melting down.

The last item is somewhat variable and indeterminate, depending largely on the local furnace and melting conditions, and time taken in charging and melting down, etc. It may be assumed, however, that both pig iron and scrap are equally liable to oxidation by the flame, so that the whole charge should be dealt with on the same lines. Further, by analogy with reheating (mill furnace) practice, it seems probable that the Fe loss will range between 4 and 6 per cent—say, 5.0 per cent mean, and that the Fe thus lost will exist as the magnetic oxide, Fe_3O_4, containing approximately 72.5 per cent Fe and 27.5 per cent oxygen. The figures will then be approximately:

Loss in melting down (say) 5.0 per cent of the total weight charged.
Equivalent, Fe_3O_4 = 7.00 per cent (approximately).
Oxygen brought in = 1.90 per cent (approximately).

These assumptions and values may not be strictly correct, but they will serve as a basis for calculations, and will be found reasonably accurate.

Increasing Wet Gas Washer Efficiency

Suggests Use of Corrugated Sheets for Baffles in Blast Furnace Gas Washer to More Thoroughly Clean Gas and to Increase Available Cleaning Surface.

By GEORGE B. CRAMP.

The principle of thorough and efficient wet washing of blast furnace gas as applied to the design, construction or operation of wet washers, is the subdivision of the gas volume to be washed, into as small bodies as possible and practicable, and bringing these subdivided bodies of gas into intimate and positive contact with as small an amount of wash water as will clean the gas to the desired point of dust content without too great a reduction in the temperature of the gas.

Positive contact of gas with wash water is secured best in those types of washers having sprays of water directed on baffles between the washed or sprayed surface of which the gas must pass in order to travel from the gas inlet to the gas outlet of the gas washer.

The efficiency of these types of washers depend upon the uniformity of water distribution; upon the uniformity of baffle arrangement and upon the amount or area of baffle surfacc, provided the baffles are arranged sufficiently close to split up the gas volume into as small bodies as possible and practicable. With these conditions in the gas washer it must follow that the greater the baffle area the greater the positive contact of gas with wash water and the cleaner the gas with a resultant use of less water, and less reduction in the temperature of the gas.

The spray nozzle has been developed to the degree of perfection where it can be depended upon to deliver a comparatively uniform spray of water over a given surface under specified conditions, and it only remains to judiciously arrange numbers of them to secure a uniform distribution of water over any area greater than one nozzle spray alone will cover.

With a uniform distribution of water provided, the vital point in wet gas washer design construction and operation is the proper selection of the baffle shape to be used in the washer, consideration of several shapes for which follow.

Fig. 1 shows two verticle plates a given distance apart between which the gas passes upward and the spray water either drops down between the plates or flows down the surfaces picking up dust from the gas that comes in contact with it. As the gas, being directed straight upward between the baffle plates will tend to travel straight up, the central core of gas does not come into intimate or positive contact with the wet surface of the baffle plates. Though it does meet the spray falling between the plates the action of the gas in traveling between the plates is so rapid that the spray is blown aside and onto the surface of the plates. These plates perform their function in confining the gas to narrow channels but being straight do not entirely prevent the channeling of the gas between them.

It would seem then that a very desirable baffle shape would be that shown in Fig. 2. It is readily seen that the courses sloped at about the angle shown would chute the films of water flowing down their surfaces from the upper surface of one course to the upper surface of the next lower opposite course while the under sides of each course would remain unflushed by water which would result in the deposit of moist dust on these surfaces. This deposit would increase until the washer would become clogged or a very heavy stream of water would be necessary to remove the deposit. A further objection to this shape is that it is not a commercial shape or one often met with even under special conditions, and by reason of its contours it could not be bent to fit within a cylindrical shell of a gas washer. To attempt to arrange straight plates of this shape in a cylindrical or square shell of a washer would result in dead ends which are undesirable because they do not maintain the uniformity.

The shape which would lend itself for use as wet gas washer baffles is the corrugated sheet represented in Fig. 3. The corrugated sheet is a commercial shape in very general and increasing use for many purposes,

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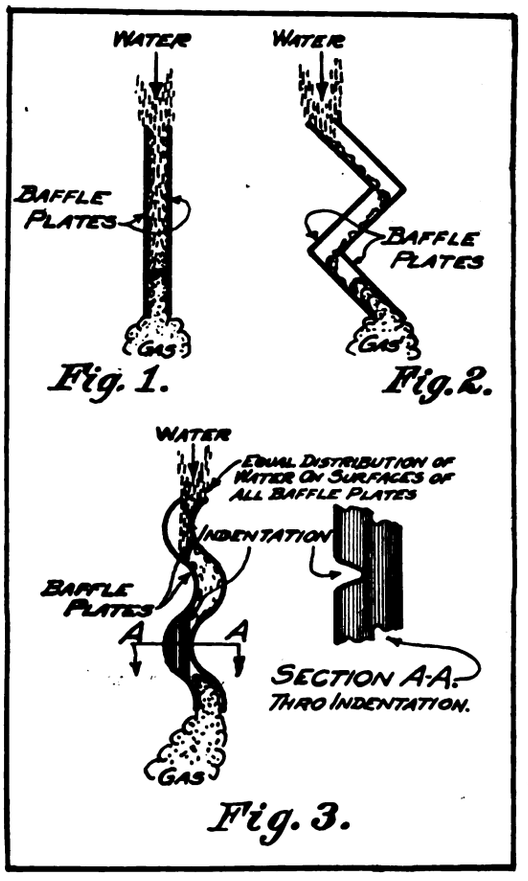
and can be readily bent without deformation of its corrugations to fit within a cylindrical shell of a gas washer. The corrugations are a mean between the two extreme shapes shown in Figs. 1 and 2, and permit the wash water to flow evenly down the entire corrugated surfaces of the plates while preventing the gas from traveling in a straight line but causing it to deviate, eddy and wind its way between the plates and bringing it time after time into contact with the perfectly flushed surfaces of the baffles and in so doing removing a far greater amount of dust from the gas.

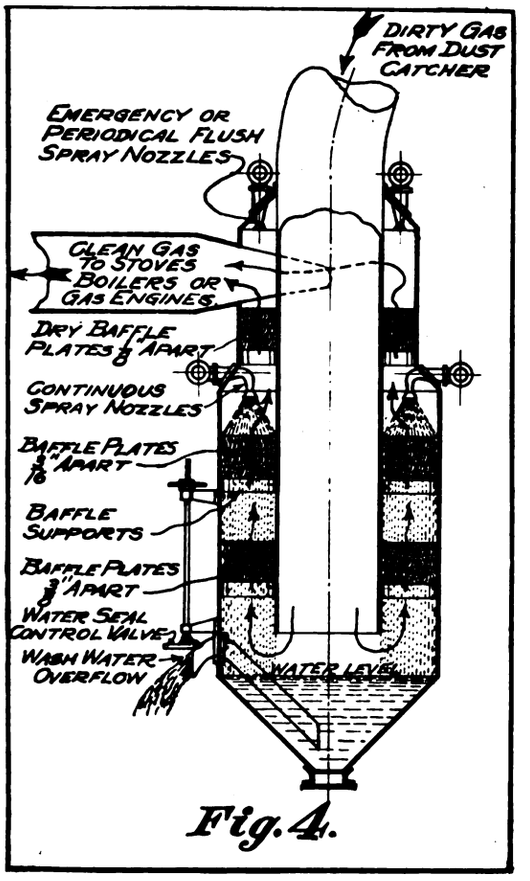
The corrugated plates could be spaced and rigidly held in the desired position by a simple indentation of the corrugation shown in Fig. 3 and Section A-A. The indentations may be provided at odd points in sufficient number to equally space the plates apart when one plate is set against another. The indentations may be further shaped so as to be in the direct path of the wash water and thereby being thoroughly flushed.



Baffles arranged thus in a cylindrical washer would give a uniform condition throughout the entire section of the washer, and an enormous baffle area greater than can be secured with any other known practicable shape.

The outline of gas washer shell is probably of less importance than the arrangement of spray nozzles and the shape and arrangement of baffles. However this matter will bear careful consideration.

The shell should be cylindrical in shape. The gas may enter the side of the washer near the bottom and leave the washer above the tops of baffles either centrally or at the side. This arrangement would leave the entire section of the washer free for filling in with baffles. The diameter of this shell could be less than the arrangement shown in Fig. 4 for an equal area of baffle surface, but the difference in diameter is so small that this feature is outweighed in importance by the points of advantage gained in the construction shown. One advantage is the entry of the gas in the center of the washer. The gas being directed downward on entering the washer tends to drop the heavier bodies of dust immediately into the pool of water al-



ways maintained in the bottom of the washer. The gas then tends to distribute itself uniformly about the center of the washer and begins to rise upward through the baffles. A further advantage is gained by this construction in that it may be readily used as a water seal valve. A further point of advantage of the larger diameter shell is gained in the shaping or bending of the baffle plates, the larger the radius of bend the easier the plates are shaped and the less deformation of corrugations will occur.

As the gas rises to pass through the lower or first set of baffles it strikes the thin edges of the plates and is immediately cut up into annular cylindrical bodies of about ⅜ inch in thickness, these films of gas pass between the wavy surfaces of the baffle plates meeting a film of water flowing down each plate with which the gas comes into frequent contact dropping the dust within it as it passes along, the water continuing its downward flow continues to pick up dust by contact

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with the gas and keeps the surfaces of the plates washed free from deposits of dust.

The rough or heaviest dust along with considerable of the finest dust is washed out of the gas in passing through the first set of baffles, after which the gas travels through the second set of baffles which do the final cleaning and are spaced 3/16 inch apart. In passing through the first set of baffles each cubic foot of gas is subjected to about 160 square feet of washing surface and in the second set to about 320 square feet. For a modern furnace installation with a gas inlet of 6′ 0″ in diameter and a gas washer shell diameter of 12′ 0″ the total area of the first set of baffles would be about 14,000 square feet and the second set about 28,000 square feet.

As the gas passes through the washer it drops its dust burden and the temperature of the gas is reduced in relation to the amount and temperature of water used. The gas may pick up some moisture in the form of vapor but if the gas is thoroughly cleaned of dust and the temperature is not greatly reduced the desired result is obtained, particularly when the gas is to be burned under boilers or in hot blast stoves. A lower temperature is probably more desirable for gas engines though if a mean temperature of cleaned gas can be allowed for all three purposes this washer will wash the gas sufficiently clean for all purposes.

Though the moisture within the gas in vapor form, may not be reduced without the reduction of the temperature of the gas thus condensing the vapor, at least any entrained moisture in the form of drops of water or even a very fine mist that the gas will always pick up and carry with it on leaving the gas washer, may be removed by subjecting the gas to impingement against additional baffle surface that is not kept sprayed. The principal applied here is the same as that in the removal of tar mist or fog from coke oven gas by causing it to project itself at a comparatively high velocity against a plate surface in small jets so that every particle of gas comes in contact with the baffle surface, and in this type of blast furnace gas washer the same results are obtained by narrowing down the washer shell at the top and inserting baffle plates ⅛ inch apart. The gas is thus caused to increase in velocity and hurl itself rapidly in small bodies ⅛ inch in thickness against the corrugations of the baffles and causing the entrained moisture to impinge on the surfaces and as more moisture collects it will form into drops and gradually flow down the baffles helping to keep the surfaces wet and acting also as a means of cleaning the gas of any remaining impurities.

If the gas is not caused to come again into contact with a spray of water after leaving the dry baffles it will pass out of the washer as free from entrained moisture as it is possible within one piece of gas cleaning apparatus to make it.

Within an annular space of 6′ 0″ inside diameter and 9′ 0″ outside diameter there may be arranged more than 20,000 square feet of impinging surface with the plates spaced ⅛ inch apart, one cubic foot of gas receiving the cleaning effect of 480 square feet; thus in a height of 15′ 0″ one cubic foot of gas receives the cleaning and drying effect of nearly 1,000 square feet of baffle surface, and the whole gas volume in traveling through the washer receives the total cleaning and drying effect of 62,000 square feet of baffle surface.

Spray nozzles may be inserted above the dry baffles to flush them should dirt tend to collect upon them. These sprays may be connected up with the furnace by means of a pressure operated regulating value which will open the spray nozzle feed line when slips occur at the furnace and insure the thorough cleaning of the gas during a furnace slip. When this is done the gas will not receive the benefit of drying surfaces as above described.

This construction being of the positive type of washer it should insure the thorough cleaning of the dirtiest gas with the minimum of wash water consumption and the least reduction in the temperature of the gas and a minimum moisture content.

Foreign Steel Standards Compared to Ours

Although American Practice Outstrips Foreign Competition in Tonnage and Cost, Higher Quality Is Predominant Characteristic of European Steel—Testing Methods More Exacting Abroad.

By MAJ. F. F. MACINTOSH.

PART I.

The following is taken from a paper read by the author before the Engineers Society of Western Pennsylvania. Maj. McIntosh was detailed as a liason officer from the inspection division of the Ordnance Department to visit England and France to study, from the point of view of a metallurgist, the methods of inspecting and of manufacturing ordnance material in those countries. Many interesting features of foreign practise are pointed out by the author. He draws the general conclusion that while this country has outstripped foreign competitors in tonnage and cost that we have much to learn from our allies as to high standards of physical quality in manufacturing steel.

I should say that the most striking feature of the foreign steel making practices is the fact that they make their additions in the furnace and test carefully to make certain that the steel is right before it is taken out of the furnace. They will not take sick metal out of the furnace and rely upon medicine in the ladle to cure it before it solidifies in the mold. This is true of the English acid practice and of the French acid and basic practices. I cannot say anything in regard to English basic practice, as the only basic practice which I watched in England was an occasional basic

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furnace making acid remelting scrap from nickel and nickel-chrome turnings.

It would not do, at this time, to attempt to describe in detail the practices followed at the different plants studied in England. There are differences from plant to plant, and from melter to melter in the same plant. I will try to make a summary of the practices characteristic of all of the English work.

Additions are never made to a heat until it is completely melted and is hot. An effort is made, particularly on heats containing nickel-chrome scrap, to melt with a neutral or a reducing flame. At one plant the temperature of every heat is checked by means of an optical pyrometer, and no additions are made to the heat until it has reached the temperature of 1,600 degrees C. At this same plant the temperature of the metal as it leaves the furnace is observed by means of an optical pyrometer and is regularly recorded. The management of this plant realizes fully, I believe, the limitations and shortcomings of the optical pyrometer, but claims, however, that it is highly advisable to use it. Its value is considered to lie in the moral effect which it has upon the workmen, and in the permanent record which it helps to give of the conditions under which each heat was manufactured. Experience has shown that the workmen first scoffed at the instrument, then became curious about it and tried to check it against the human eye, and finally reached a point where they have enough respect for the pyrometer to consider it as a check upon their ability to judge temperature, and show considerable pride in being able to foretell by the eye what the reading of the pyrometer will be. The optical pyrometer, usually of the Fery type, is used much more for all kinds of work in both England and France than is the case in this country.

It is universally considered important to have heats well melted and hot before any additions are made. It is considered of even more importance to have the heat thoroughly deoxidized and hot before tapping. Any free iron oxide in the slag at the time of tapping is considered to be fatal, and the slags in some practice will run as high as 60 per cent silica. The hot, highly acid slag has a deoxidizing effect on the metal. The slag should be hungry for bases, and if analyses of the slag before and after the addition of deoxidizing agents show that the slag has been deoxidized by the additions, then it would be said that the slag had not been sufficiently acid at the time the deoxidizers were added to the metal. The condition of the slag is watched with as much care as is the condition of the metal. Towards the end of a heat the slag should not show any dark colored streaks. These dark colored streaks or spots in the solidified slag are supposed to indicate that the slags contain free oxides. With free oxides in the slag the metal could not be properly deoxidized.

The deoxidizers are all added to the metal in the furnace, and samples of metal are tested by forging before the heat is tapped from the furnace. The old method of taking test samples which are allowed to cool under a layer of slag is quite generally followed and they seem to consider the appearance of the surface and fracture of this test a reliable index of the condition of the heat.

The ladles are merely dried out by means of wood or coke fires, and would be considered as cold ladles in this country. Yet a 40 or 50-ton heat of steel will be teemed through a ¾ or ⅞-inch nozzle without leaving a skull in the ladle. It requires a hot and thoroughly deoxidized metal to meet this requirement. Observation of the finished machining operations and the physical testing of these steels shows a metal very free from inclusions of foreign material. There is a marked difference in this respect between the English steels and the American made steels; a difference in favor of the English steel.

It is the belief of well informed English steel makers that deoxidation in the ladle brings about chemical reactions which result in non-metallic materials, such as silicates, oxides, sulphides, etc. These reactions, giving non-metallic materials, are still going on as the metal solidifies, and this reaction results in numerous small non-metallic inclusions scattered all through the metal. The fact that inclusions of this kind are much more numerous in American steels than in English steels indicates the soundness of their contention. If our cannon steels were forced to meet bending and impact tests as are the English steels, this matter of small foreign inclusions would immediately become a matter of grave importance.

The outstanding feature of the English ladle practice is the use of small nozzles, and, in many cases, the use of more than one nozzle on a ladle. On heats running up as large as 80 tons, nozzles from ¾ to 1 inch in diameter will be used. The fact that large heats are teemed through such small nozzles without leaving a skull in the ladle indicates clearly the temperature and character of the steel. In order to teem large heats of steel through small nozzles, many manufacturers resort to a composite nozzle; that is, a nozzle of which the forward part, or the part towards the outside of the ladle is made of magnesite and the inner part is made of clay. These nozzles are made in two pieces and fit together. I have measured a ¾-inch nozzle of this type through which a 40-ton heat of steel was cast, and the magnesite portion of the nozzle was practically of the original size. It is very common, but not universal, practice to use two stoppers and nozzles on a ladle. In such cases a ¾ or ⅞-inch nozzle is the nozzle through which the heat is to be teemed. The second nozzle is held for an emergency, and will vary from 1¼ to 2 inches in diameter.

All of the large work is top-cast, and bottom casting is resorted to only in cases where it is desirable to secure a particularly good surface on the ingot, or to cast a large number of small ingots at one time. It seems to be a general belief of the English steel makers that bottom-cast ingots contain more inclusions of foreign material and are less sound than the top-cast ingots. In one instance I was shown the results of a series of experiments on bottom poured steel for axles, which gave from 8 to 10 per cent rejection of material for dirty steel. The same material, top-cast, gave a rejection of about one-tenth of 1 per cent for dirty steel.

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On all large work, hot tops are used and the ingot is placed on a bottom plate containing a good-sized pouring basin.

The question of inverted ingots for forging work of this kind has resolved itself largely into the question of the character of the particular forging for which the ingot is to be used. It is generally conceded that an ingot cast with the large end up and hot top will give the maximum degree of soundness along with the maximum horizontal extension of segregation. The same casting, with hot top and small end up, gives less horizontal extension of segregation and confines the segregation and unsoundness more to the vertical axis of the ingot.

The English are carefully studying the design of ingots with reference to the character of the metal in the finished forging. They realize that there are some factors more important than the percentage of reduction in forging.

I fear that our specifications contain requirements—such as a requirement of a four-to-one reduction in forging—which are matters of tradition and inheritance, rather than scientific principles. There is evidence that our requirement as to reduction in forging is one of these traditions, and that it does not work to give us the best possible steel in the finished gun.

The English method of attacking this problem is largely by means of taking sections of finished forgings, and also sections of ingots, and etching them with an acid cupro-ammonia reagent which displays to the unaided eye the original ingot structure in the ingot itself, or in the finished forging. This is a very interesting line of work which is giving valuable results to those who are following it up.

The most striking feature of the English forging practice was the heating of the metal for forging. In all cases, forgings are heated in coal or gas-fired furnaces. These furnaces give a soft, even heat without excessive scaling of the forgings, or spotty heating, or danger of overheating.

To my mind, there is no room for dispute as to the relative value of coal or gas for this work as compared with oil. I believe that the sharp cutting flame of the oil-fired furnace has been the source of a large amount of trouble, and the cause of injuring much steel in this country. This sharp cutting flame is not only hard on the metal, but is very destructive to furnaces, whereas the soft, even heating of the coal or gas-fired furnaces gives metal in which the heat is well soaked through, metal which has not scaled badly, and gives furnace life much greater than can be obtained with the best oil-fired furnaces. In many instances waste-heat boilers were used to very good advantage on the forging furnaces.

It is common practice to use crescent-shaped or V-shaped dies for forging but, in one or two instances, large manufacturers were using straight-faced dies with excellent results.

The temperature of forgings was rather carefully watched at all places. In most cases the workman's eye would be checked up from time to time by use of an optical pyrometer.

It was the general custom to heat the forging to about 1,250 degrees C. With the use of coal-fired furnaces, there was much less danger of local or general overheating of this work than would be the case with oil, working at this temperature. It is very easy to understand how metal heated to 1,250 degrees C. in an oil-fired furnace could be locally damaged by overheating, or by superficial heating.

Some of the most successful manufacturers were careful to stop all work on a forging when its temperature had fallen to 800 degrees C.

One metallurgist held very strongly that it was his belief that the temperature at which forging should be stopped was not so much a matter of where the critical point of that steel lay, as it was a matter of the physical strength and characteristics of the metal at different temperatures. He felt that the danger point in forging would vary with the character of the steel with reference to its chemical composition, rather than with reference to its critical point. This is an interesting belief which is grounded on experience rather than on theory. The general experience of all forgers seem to be that forging at too low a temperature might cause internal tears in the metal.

I believe that our English cousins would be amazed at the beautiful equipment and at the facilities which we have for heat treatment in this country. They are old hands at the heat treating game, and do not take it quite as seriously as we have done. Their experience seems to point to the fact that if they make good steel and forge it properly, they will have a wide latitude in the forging and in the heat treating.

I should say that more than 50 per cent of the cannon forgings are heated in horizontal furnaces. The quenching is always done in a vertical position. The pyrometric equipment on these heating furnaces is very simple indeed. In most cases is consists largely of the workman's eye, aided either by water pyrometers or an optical pyrometer.

For drawing or tempering work, pyrometers are much more generally used. Base metal couples are used for this work. In many instances the forgings are turned by chains during the tempering operation. The general practice is to inform the workman that such and such forgings are to be heated to 1,600 degrees F., or whatever the desired temperature may be. The workman places the forgings in the furnace, examines them from time to time, and when he believes that they have about reached the desired temperature he will check his eye either with an optical pyrometer, or by means of the Seaman water pyrometer. Occasionally thermo-couples are used for this work, but nowhere will one see the elaborate pyrometric equipment which is to be found in this country.

When the forging has finally reached the desired temperature, it is kept at that temperature for a short time, varying from 15 to 30 minutes, removed from the furnace and quenched. In general, the quenching temperatures used are higher than those employed in this country, and the time of heating is much shorter. A comparison of their results with ours would indicate that in most cases we have followed theory too closely.

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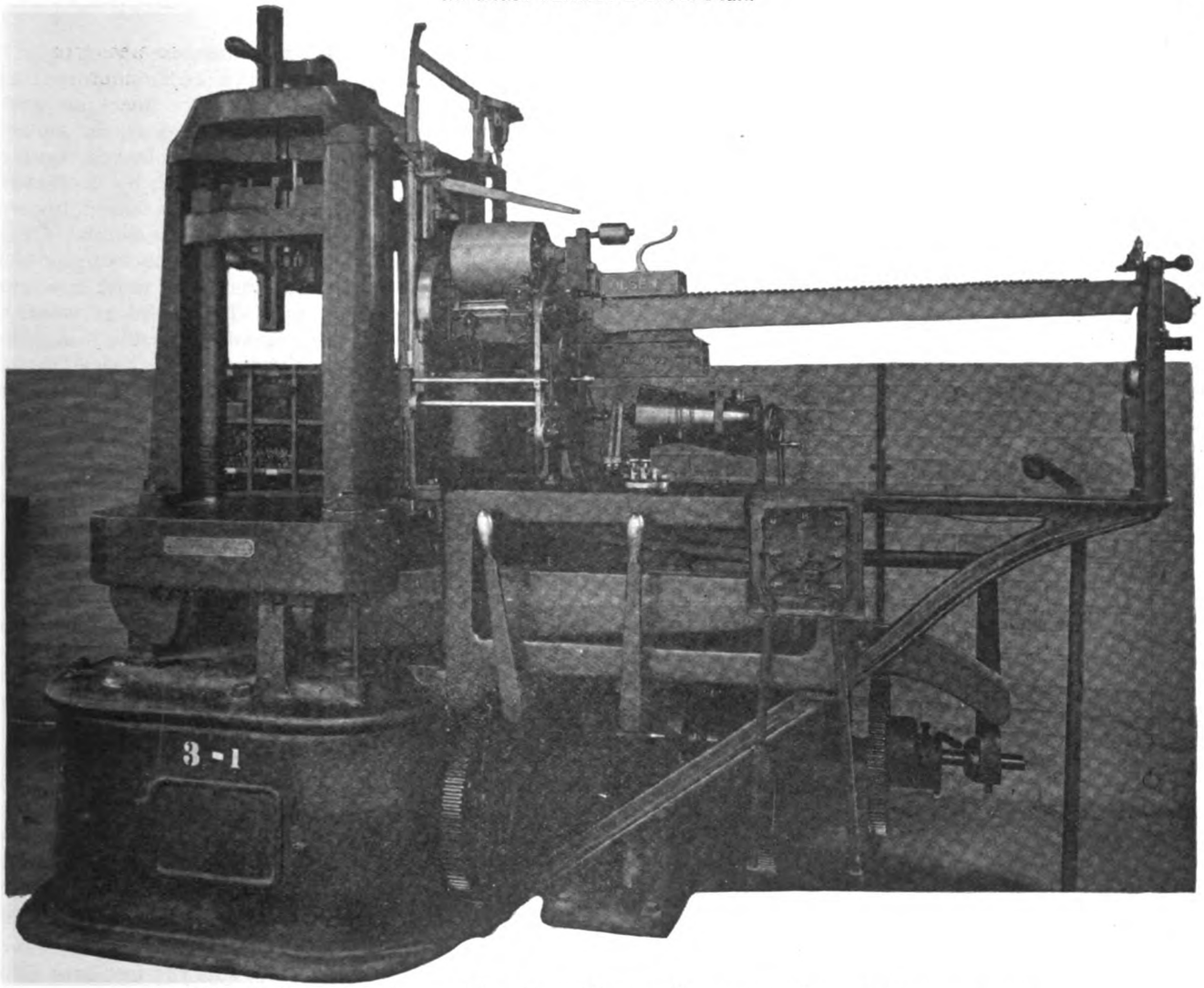

Olsen Universal testing machine for making tensile, compression and transverse tests.

Practical Notes on Physical Tests of Steel

The First of a Series of Three Articles Dealing With the Physical Tests of Metals—Details of Testing and Testing Machines. First Article Deals With Tensile and Compression Test.

By AUSTIN B. WILSON.

PART I.

All engineering materials are subject to varied and complex stresses which are impossible to calculate, and which cannot be duplicated in testing. Some factor of the test must be greatly exaggerated to produce rapid failure and this it must be obvious, alters greatly the working conditions. In view of this the fundamentals in physical testing are that one physical property must be tested at a time and that the results must be comparable regardless of the size of the test-piece within reasonable limits.

There are two classes of tests in use, "static" tests in which the load is applied slowly, such as in tensile tests, and "dynamic" tests where the load is applied more or less rapidly, as in impact tests.

Before describing the details of testing, testing machines, etc., it will be well to briefly define the terms which will later be used. The "tensile strength" is the maximum load in pounds per square inch which the material can stand without breaking. The "elastic limit" is the load at which the first permanent set occurs. The "yield point" is the load at which in low-carbon steel the first noticeable elongation takes place. In bronzes and high-carbon steels it is the load at which under tension the metal stretches one-half of 1 per cent of its original length. This is an arbitrary point set by the A. S. T. M. for comparative purposes. "Elongation" is the increase in length which a bar undergoes when subjected to sufficient tensile stress to cause fracture. "Reduction of area" is the amount of contraction of cross-section which takes place in

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the bar at point of breaking. The elongation and reduction of area are, in pieces of the same material, very good indications of the ductility which may be expected. All of the above properties may be easily determined in making a tensile test.

The elastic limit or the yield point should always be determined in testing as this has possibly the most important bearing on the service which may be expected from the material in question. Up until this point has been reached we have been dealing with a purely elastic material, but once this point has been passed, the metal is more or less plastic and failure is comparatively rapid, even though no stress approaching the maximum limit is placed upon it. The "proportional limit" is in reality the correct designation for this point instead of "elastic limit" as it marks the load at which the strain ceases to be proportional to the stress.

The testing apparatus of which illustrations will be shown and the tests which will be described in this series are only those with which the writer is familiar. The photographs are from the laboratory in which the author is now employed. The methods of testing are in accordance with those most generally used in this country and except where so stated they are equally applicable to steel or bronze.

The tensile test is the most popular form of test and, therefore, it is evident that from the results of this test, the engineer will know just what he may expect from the material in the way of service. Therein lies its value. It also fulfils the fundamentals of physical testing as given above. It does measure one physical property, namely, strength in tension, and it is within limits independent of the size of test-piece.

A testing machine of the most popular type is shown on the previous page. This machine is known as an Olsen universal testing machine and is equally suited for making tensile, compression or transverse tests. It consists fundamentally of two parts, the first that by which the load is applied to the test-piece and the second the mechanism by which the force applied is measured. A tensile test-bar is shown in position between the upper and lower cross-heads. The lower end of the bar is held by means of V-shaped wedges which grip more tightly as the stress on the bar increases. These grips may be obtained for holding almost any form of test-piece. The load is applied to the test-piece by means of the lower cross-head which moves up or down as desired, and in which similar grips are held. It moves freely being actuated by the large screws shown which pass through holes in the bed of the machine. These screws are driven by means of the gearing shown which is in turn driven by a two-horsepower motor. The cross-head can be moved at four different speeds varying from ¼ inch per minute to 4 inches per minute. The speed is controlled through the two levers shown. The motor is reversible and the direction in which the cross-head moves is governed by the double-throw switch. The upper end of the test-piece is held in the same manner as the lower except that the grips are fitted into the stationary upper cross-head. When the lower cross-head moves downwards a force is exerted upon the test-piece and through the test-piece upon the upper cross-head. This cross-head is supported upon pillars attached to the bed of the machine and to which resting upon knife edges the force is conveyed. By means of a system of levers the bed is connected with the beam which is traversed by a traveling jockey-weight. This arrangement is based upon the same principle as a pair of scales. As the force is applied the beam rises and the jockey weight is run out either by hand or automatically until it counterbalances the force exerted. The speed at which the jockey moves when running automatically is regulated by the cone pulleys shown. The beam may be balanced before starting by adjusting the small cylindrical poise shown above the jockey. Forces up to 100,000 pounds can be exerted and measured by this machine. The beam is graduated for every 2,000 pounds and the intermediate readings are obtained from the flat disk at the extreme left end of the beam. By using the jockey-weight shown direct readings may be taken but for specimens of small cross-section smaller jockeys may be used and more accurate results obtained. The large cylinder is for making autograph records of tests. One of the two keys below the cone pulleys controls the mechanism which drives the jockey-weight, the other that which makes the autographic records. The jockey is moved by the screw over which it sets and which moves whenever the stress applied is great enough to raise the right end of the beam as high as it will go. This makes an electric connection and the weight moves along until it counterbalances the force exerted when the beam drops and breaks the connection. If by any chance the beam should not balance properly the bell rings and warns the operator that all is not right.

For strictly comparable results the test-bars should be of the same shape and approximately the same size. The ends may or may not be threaded but for research work threaded ends are preferable as they allow of less variation such as is sometimes due to the slipping of the grips. The most popular size of test-piece is ¾ inch in diameter at the ends, with a 2-inch gauge length in the center of ½ inch diameter. The radius of the shoulder which connects the gauge length with the ends should be about ⅝ inch. Very satisfactory and consistent results are obtained from bars of this size and shape although other forms may be equally as good. Often, however, it is impossible to obtain test-bars of the above dimensions from the material which it is desired to test. This is especially so in the case of sheets, wires, etc., which are of too small cross-section. For testing sheets or materials which have parallel sides and which are too small to be machined to the above size it is customary to machine the gauge length through the edge of the material and to hold the bar between flat grips furnished for this purpose. Wires are not machined but are tested as drawn. They also are held between flat grips the gripping surfaces of which are covered with fine teeth.

The actual testing and operation of the machine are comparatively simple although some knowledge and skill are absolutely essential to conducting the test properly. First the diameter of the test-piece

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on the gauge length from which the cross-sectional area is computed, is measured. This is done by measuring the piece in several places with a micrometer-gauge and taking the smallest diameter found. For doing this properly a certain degree of delicacy of touch is needed. After noting the diameter two very light punch marks are made on the gauge-length exactly two inches apart. A small two-pointed punch is used to make the marks. This punch is made from one piece of steel so all chance for error in the distance apart at which the marks are placed, is avoided. The bar is now ready for testing. It is placed with the upper end gripped by the jaws in the upper cross-head. It is adjusted until absolutely parallel to the direction in which the cross-head moves. The beam is now balanced until it floats free after which the lower jaw is coupled on, contact made through the right hand key and the lower cross-head started downward. As soon as the pressure is felt by the test-piece it is transmitted as described above, the beam rises, makes contact and the jockey-weight moves out until the pressure is counterbalanced and the beam drops. Increased pressure soon causes it to rise again and make contact and so on until rupture occurs when the stress is noted and the maximum strength computed therefrom.

As the pressure is first applied and for some time thereafter there is no visible change in the specimen. Nevertheless by means of delicate instruments a measurable amount of stretching can be detected. The metal, however, during this time behaves as a purely elastic material, i.e., the deformation disappears entirely upon removing the load. The stretching is also found to be proportional to the load.

When a certain point is passed the stretch ceases to be proportional to the load. This is the "elastic limit" and is one of the most important points in the behavior of metals under strain as it marks the first permanent set in the metal and is the point at which micro-structure begins to break down under strain. It will be further dealt with in discussing "fatigue" failures. Owing to the care and time necessary for its accurate determination the true elastic limit is not usually determined in commercial practice. Instead it is customary to find the "yield point" which is always somewhat higher than the elastic limit.

There are several ways of finding the yield point. In testing "mild" steel it is taken as the point at which the beam first drops on to the lower support and remains stationary for a noticeable length of time although the cross-head of the machine continues its downward movement. In testing bronzes and high-carbon steels this "drop of the beam" does not occur. It, therefore, becomes necessary to set some point which shall be taken as the yield point and to determine this by means of suitable instruments. This point has been set as described above. It may be found with a pair of dividers set so as to equal 100.5 per cent of the original distance between the punch marks, i.e., 2.01 inches on a 2-inch gauge length. One point of the dividers is set in the lower punch mark and the dividers are moved back and forth sidewise until the bars stretches sufficiently for the other point to fit into the upper punch mark. This method is at best quite rough and it requires considerable experience on the part of the operator to judge the exact time at which the reading should be taken. In cases where the yield point is very high the chance of error is greatly increased as the increase in stretch is very small compared with the increase in load. For accurate determinations in such cases either Capp's dividers or a Berry strain-gauge may be used. The latter is preferred by the author. It is easily adjusted, has a dial about the size of a watch, can be read to 1/5,000 of an inch and has few parts to get out of order. It is merely held with its two points (one stationary, the other moveable) set in the punch marks until the desired stretch takes place, when the reading on the machine is noted.

After the yield point is passed the metal continues to stretch under the continually increasing load until rupture occurs. This, however, is not true of some particularly ductile materials, such as mild steel. In this case just before rupture occurs the metal reaches a point where the stretch is not the same over the entire length. A portion of the piece becomes constricted and "local necking" occurs. Elongation takes place rapidly at the constricted portion. The stress per square inch of area at that spot increases rapidly and the piece breaks although the actual load is considerably less than that at which "necking" began. Thus it will be readily seen that "ultimate" strength and "maximum" strength are not the same although they are frequently used as such in describing tensile tests. The ultimate strength is of relatively little importance and is only determined when scientific investigations are being made. The maximum strength is always determined.

The broken test-piece is removed from the testing machine and the two ends of the bar fitted together as closely as possible. The distance between the two punch marks is measured and the percentage of elongation computed from the increase in distance between the marks.

Now the diameter of the bar at the point of fracture is measured with micrometers and the percentage of reduction of area computed from the difference between the original and reduced areas. This is usually easily done but sometimes the bar is so distorted that it is almost impossible. If this occurs, an average of the largest and smallest diameters at the point of fracture is taken.

In case the bar breaks outside of the punch marks neither the elongation nor the reduction of area are measured. Both of the above properties are used in estimating the ductility of the metal. Although the writer will not attempt to discuss the reason, let it suffice to say, that the reduction of area is considered by most engineers and metallurgists as the better criterion as it is less affected by the size and shape of the test-piece.

Compression tests as mentioned are also made on this machine. A block of hardened steel is placed upon the bed of the machine and a thick plate, also of hardened steel, clamped on the lower side of the

(Continued on page 447.)

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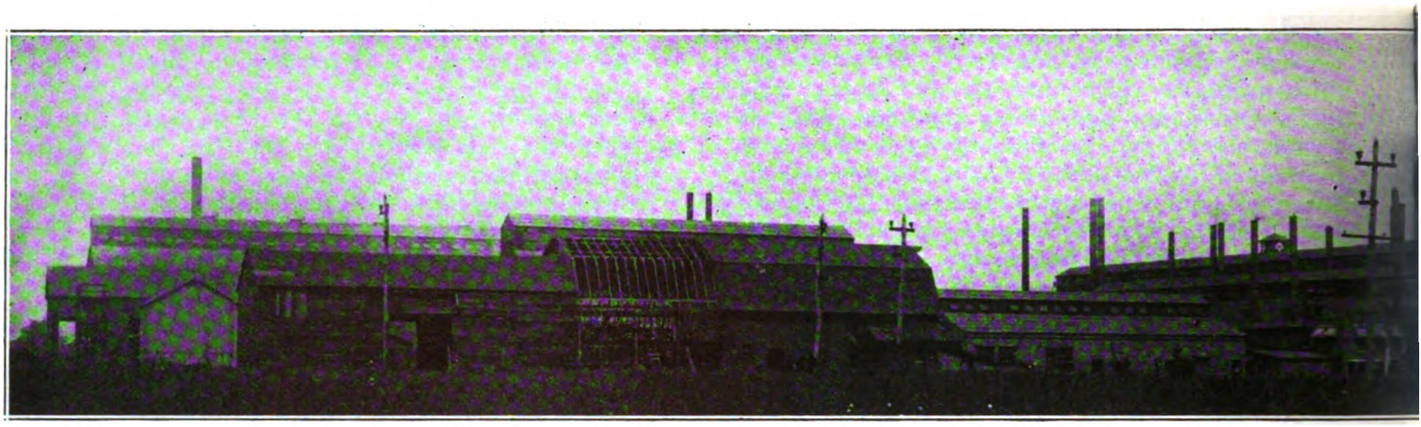

Atlas Crucible Steel Making and Rolling

Crucible Steel Company Increases Furnaces and Two Heroult Electric Natural Gas and Producer Gas Used—

By H. DONALD

THE Atlas Crucible Steel Company had its beginning in 1907, a beginning, however that was preceded on the part of its founders by years of practical experience and studious application to the art of making the best tool steel. Upon this foundation has been erected in 12 years an institution 12 times its original size, and around it has gathered a community of men of ability—mechanics, engineers, chemists and metallurgists—all imbued with that unity of spirit and breadth of view that means constant advancement in the production of a perfect product. The very best of modern equipment is placed at the disposal of these men, and their work is performed in quarters as desirable and attractive as it is possible to furnish. These conditions result in the attainment of the highest possible efficiency and in a quality of finished product that places it in a class by itself.

The company is very fortunate indeed to be located as it is, in Dunkirk, N. Y. It has practically an unlimited area in which to expand and any expansion will not jeopardize its transportation facilities. The plant is situated on the main lines of the Nickel Plate and Allegheny Division of the Pennsylvania Railroad, which makes it possible to make and receive shipments with minimum delay.

View of six-ton Heroult electric furnace in operation.

The capacity of the plant at the present time is 11,000 tons of steel per year and, to produce this, the services of approximately 700 employes are necessary. The building program of the company is extensive to say the least. The growth of the plant has been rapid and work is now under way on an extension to the present hammer shop and 14-inch mill building. Recently, the company acquired a large one story factory building and have turned it into a wire mill for making drill rods. This building is of modern type and is located on the opposite side of the railroad from the main part of the plant.

Because of the unlimited area in which to lay out the plant, large storage yards are provided for the reception of raw materials used in the manufacture of their product. The yards are served by a locomotive crane which facilitates the handling of bulk material. The main storage yard is divided into bins and the material after its grade and analysis have been determined is put into these bins which are carefully marked. The alloys, however, are stored in a separate building constructed for this one purpose.

The melting department is one of special interest because of the crucible melting furnaces. These furnaces are housed in one end of a building 400 feet long by 70 feet wide. There are three of them, each with a capacity of 30 100-pound crucibles. These crucible furnaces are equipped with regenerators, reversing

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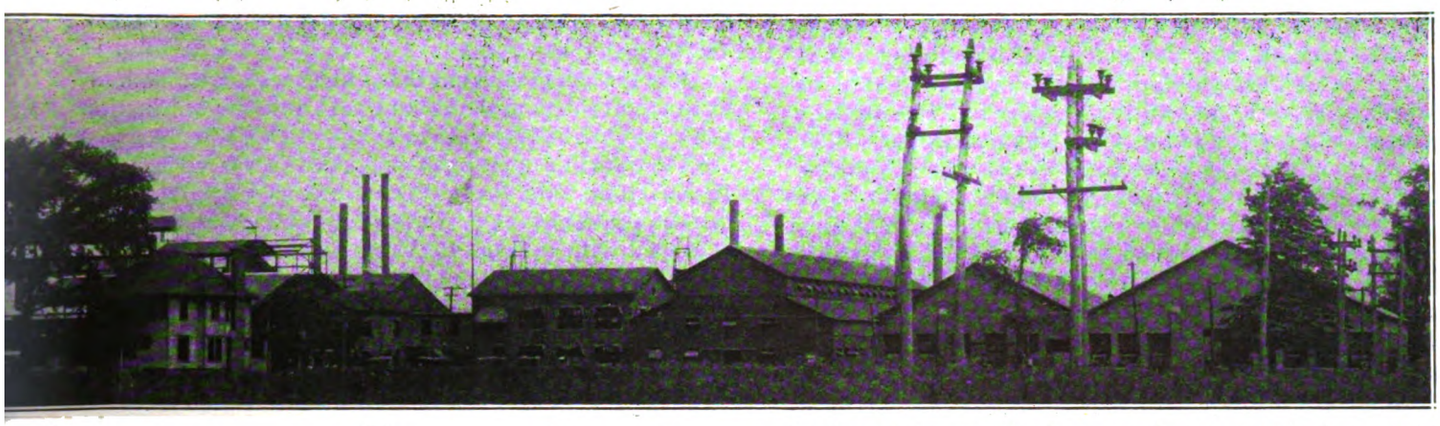


Increases Capacity for High Grade Steels

Capacity — Three Crucible Melting Furnaces Used for Melting Steel. Mills and Hammers Reduce Ingots.

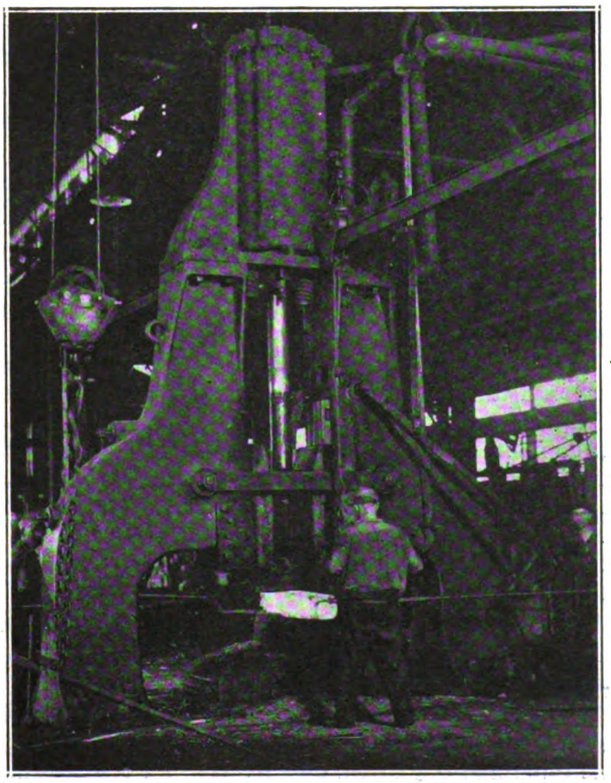
DICKINSON.

valves, chimneys and gas producers. The furnaces and gas producers were built by William Swindell & Bros., Pittsburgh, Pa. Both producer and natural gas are used for fuel—natural gas having been found in the vicinity of Dunkirk, in sufficient quantity to make its use very economical. As in open hearth practice, the furnaces are heated and controlled in the same manner, with the exception that the crucible furnaces and recuperators have a proportionately smaller heating surface. The furnace chamber is placed below the floor level, the movable arched roof alone standing above the level of the floor. The cover is constructed of firebrick, keyed into an iron frame, equipped with eye bolts for removing the cover from the hole. The heating chamber stands on an arched vault between the two pairs of regenerators which are located at each side of the melting hole.

The furnaces are rectangular in shape, each hole being 37 inches long 22 inches wide and 38 inches deep. These are so constructed as to hold 30 crucibles arranged six in a hole, each pot having a capacity of 100 pounds of metal. The roof is made of removable segments and each crucible pit is covered by one of these segments. To prevent the crucibles from fusing to the brickwork in case any of the molten metal spatters out of the crucible, the longitudinal walls of the melting hole bottoms are covered with coke breeze to a depth of about six inches. The furnace is provided with a tap hole located at the bottom. In case a crucible breaks while in the furnace this tap hole may be broken open by a pointed bar and the metal run into a tunnel underneath the furnace.

Puddled bar iron and alloy scrap are the principle ingredients used in the manufacture of crucible steel. These materials have been previously assorted and broken into small pieces and are weighed up into crucible charges of 100 pounds each. The charge is placed in the crucible by hand. the cover being then put on the crucible. After this has been done, the latter is placed in the furnace, the melting hole cover is set in place and the gas turned on.

The old pulling out system of removing the crucibles by hand is still used. The removal of the crucibles from the hold by hand is perhaps the hottest job connected with the steel industry and the "pullers-out" are provided with appliances to protect them from the heat. When the charges are melted down. the producer gas flow is throttled down sufficiently to permit the introduction of tongs having concave jaws. These tongs are placed a trifle below the center of the crucible and the latter is lifted from the hole. With a little experience, the puller-out can judge the amount of pressure needed to be put on the crucible



Six-ton Bell hammer in operation.

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so that it can be drawn out without danger of it slipping from his grip.

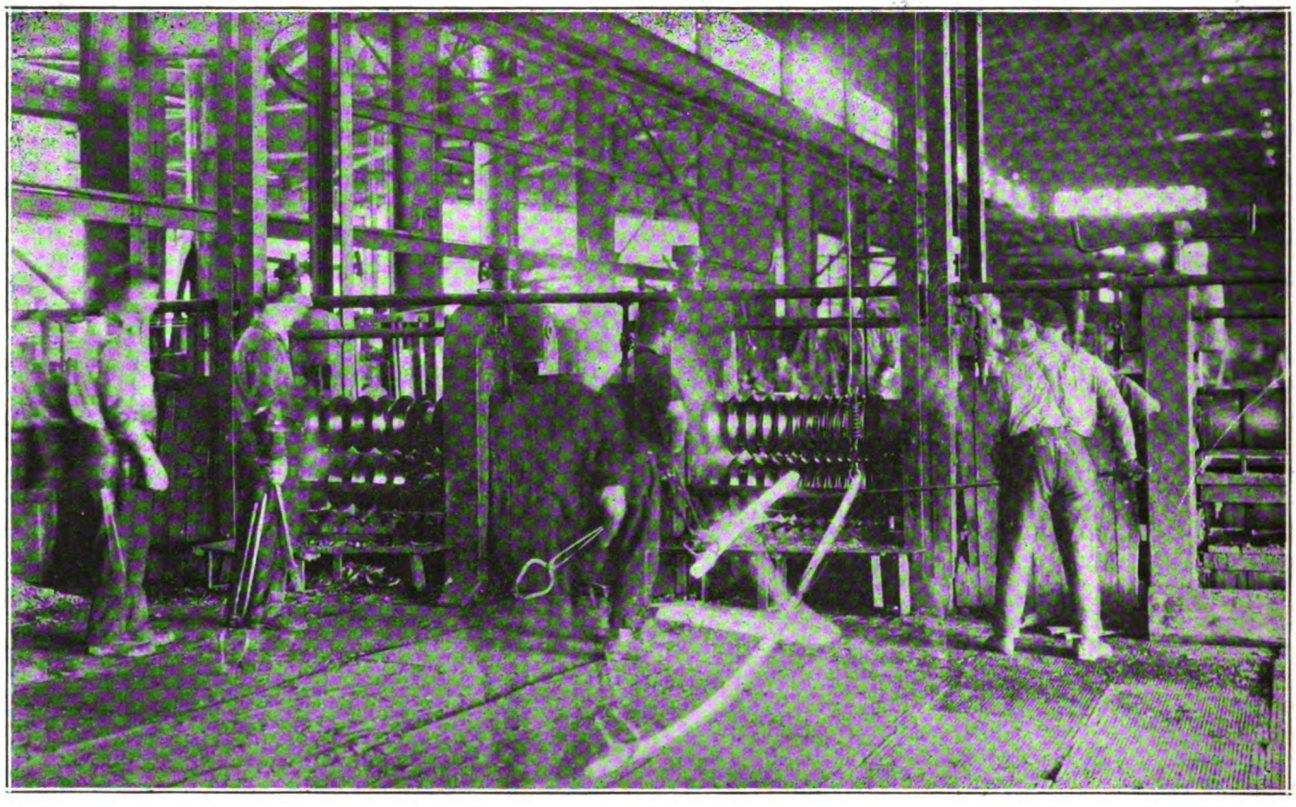
The crucible with its charge of molten metal having been withdrawn from the furnace and placed on the floor, is set in a tilting device and its contents poured into a 1-ton ladle. The empty crucible is then taken to one side, inspected for cracks, and if found to be in good condition is recharged while still hot. This practice of recharging the crucibles while hot not only minimizes the amount of heat required but greatly reduces the time required for melting. The crucibles are made of graphite and have a life of from four to seven heats, depending on the steel made, while approximately 1,000 heats of steel can be made without relining the furnace. The furnace lining lasts 9 or 10 months.

holder, located on the furnace top. The power requirements are 750 kw hours for the 3-ton furnace and 1,500 kw hours for the 6-ton.

The molten steel from these furnaces is also poured into a bottom pour ladle and cast into ingots in the same manner as the steel from the crucible furnaces.

The crucible melting department is served by one 10-ton crane, and the electric furnace department by two 25-ton Cleveland overhead traveling cranes each equipped with a 5-ton auxiliary hoist.

The steel from the melting department is taken to the various rolling mill departments over an industrial track system. This track system is so arranged that the products from any of the departments can be transferred to the various parts of the plant with a minimum of delay due to unnecessary handling of the material.



View of 14" mill.

The entire heat of steel is poured from the pots into a 1-ton bottom pour ladle suspended from one of the cranes. The ladle is carried to the mold pit and its contents poured into the various size molds. After the ingots have "set" they are withdrawn from the molds, carefully graded, annealed and analyzed, and are then ready for rolling. Both single and two-piece molds are used, ranging in size from 8x8 inches to 19x19 inches.

The practice of pouring a heat of steel from the pots into one ladle and then into molds, produces ingots with uniform chemical analysis.

Steel is also made by the electric furnace process. At present the electric furnace equipment consists of one 6-ton and one 3-ton, 3-phase Heroult type furnaces. Each furnace has its three electrodes placed in the

Two processes are employed for breaking down either the crucible or electric steel ingots. It is done either under a steam hammer or in a cogging mill. The steam hammer equipment consists of one 6-ton Bell hammer, one 6-ton Chambersburg hammer and one 4-ton Niles-Bement-Pond hammer. Each hammer is served by three furnaces and a 5-ton jib crane. Approximately 40 tons are broken down per day and all the ingots broken down under the hammer into billets or slabs are transferred to the bar mill.

After the billets have been taken from the forge department, they are put on grinding machines which remove all surface defects. The billets are then placed into coal fired regenerative furnaces and heated to the desired temperature. Upon reaching this temperature, they are withdrawn and passed through the rolls

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of the 14-inch mill. The latter which was built by the Lewis Foundry and Machine Company of Pittsburgh, consists of four 3-high stands and is electrically driven by a 700 hp Westinghouse variable speed motor. This mill rolls rounds from 1 to 4½ inches. If specifications call for rounds of smaller diameter, they are rolled as usual through the 14-inch mill and then taken to the 10-inch mills.

The 10-inch mills are two in number and will finish rounds from 7/32 inch up to 2¼ inches. One mill was built by the Lewis Foundry and Machine Company and the other by the Hoagland Company. One mill is driven by a Burke constant speed motor of 400 hp and the other by a 450 hp Westinghouse variable speed motor. All mills are the Belgian bar mill type.

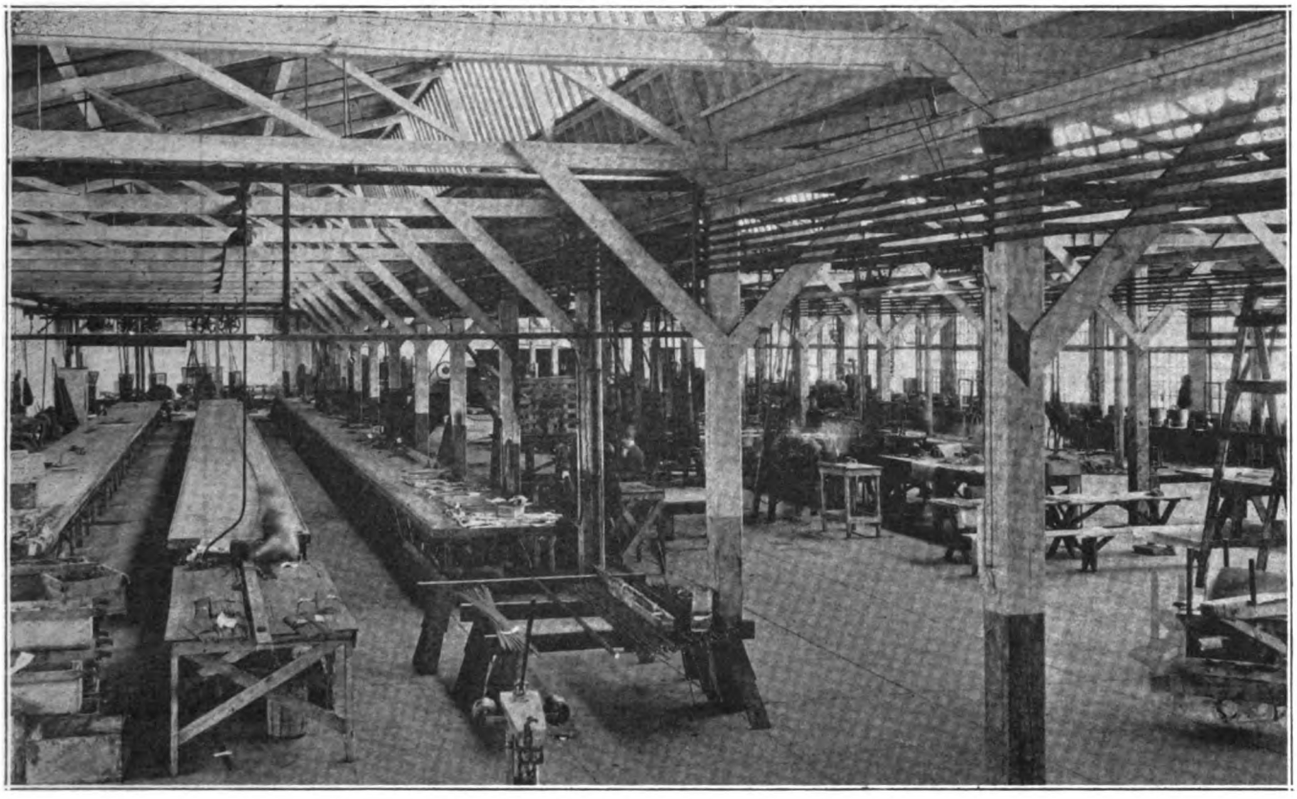
These mills are all served by electric traveling cranes. Three furnaces are required for the 14-inch mill and two for each of the 10-inch mills. The heating furnaces were designed by the company and use soft coal for fuel. They are fully equipped with optical and recording pyrometers.

Products from the mills, when so ordered, are annealed by the closed fire method. In closed annealing, the bars are packed in charcoal in a pipe. The pipe is then placed in the furnace and the bars given the desired anneal. The pipes are then withdrawn from the furnace, the bars removed and placed in cooling vats.

The annealing furnaces are five in number, four being Swindell coal fired and the other of the Rockwell oil fired car type. The temperatures in all are controlled by indicating and recording pyrometers.

The steel after it is received from the mills or hammers is weighed, gauged and carefully inspected. It is then stamped with the grade and temper. Each bar then undergoes a second rigid inspection for imperfections and defects; the ends are nicked and broken off to determine the fracture. The bars which become bent in the process of annealing or handling are placed in a straightening machine and straightened. The steel is then weighed and bundled if in quantities of 100 pounds or over and boxed if in smaller quantities. The steel is then ready for shipment.

The company is fortunately located near Niagara Falls and electric power is purchased from there, thus doing away with the necessity of maintaining a large power plant of its own. The current is received at 60,000 volts and stepped down to 4,000 volts for use in the electric furnaces and mill motors.



Main building of wire drawing mill.

The steam power plant contains four 150 hp and two 100 hp return tubular boilers. Coal is used for fuel and the boilers are hand fired, no stokers being used.

Careful attention is paid by the Atlas Crucible Steel Company in selecting the materials used for making the steel in the electric and crucible processes, and in connection with this an up-to-date chemical laboratory is operated. Test samples are taken at various stages of the melting processes and analyzed so that the resulting steel may be of the desired composition.

The company maintains sales offices in all the principal cities in the United States and Canada and warehouses in Cleveland and Detroit.

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Compressed Air Operated Pickling Machine

Installation of Mesta Pickling Machine at Consolidated Expanded Metal Company Utilizes Compressed Air to Avoid Installing High Pressure Boilers—Tests Indicate Satisfactory Results.

The Consolidated Expanded Metal Company, Braddock, Pa., has recently placed in operation a pickling machine operated by compressed air, which is giving good service. The pickling machine is of the Mesta type. The standard Mesta pickling machine is of the steam driven type and consists of a vertical reciprocating plunger with a spider of three or four arms carrying crates which move up and down in the pickling and rinsing baths. The steam consumption of these machines is 1,000 pounds per hour, and they are economical in operating cost, since they furnish just about enough exhaust steam for heating the pickling bath. And since steam is needed in any installation for heating the pickling bath there exists no incentive for replacing the use of steam for operating the plunger of the machine with any other form of motive power.

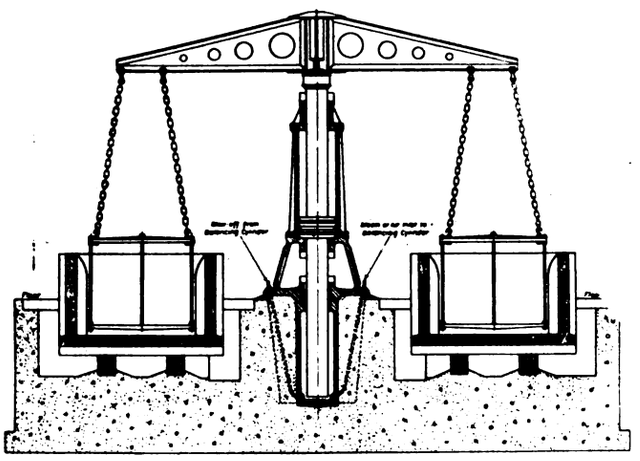

Fig. 1—Mesta pickling machine.

In view of these circumstances it will appear surprising, at first, that the Consolidated Expanded Metal Company in Braddock, near Pittsburgh, decided to install a Mesta pickling machine operated by compressed air. The reasons which caused the Consolidated Expanded Metal Company officials to select compressed air as a driving medium in preference to steam were conditions of power supply and layout of their plant. At the works in question, no high pressure steam is generated. All power is purchased in the form of electrical energy and such steam as is generated is of low pressure for heating purposes only. The installation of high pressure boilers within the limited space available would have meant considerable trouble in the quick and successful operation of the plant. In order to retain and benefit by the advantages of the Mesta pickling machine, though having no suitable steam pressure available for its operation, it became necessary to use the roundabout way of first producing compressed air and then using this air in the pickling machine.

Some apprehension was felt on account of the probable high rate of air consumption in a machine designed to be steam driven. It was feared that the air consumption of the machine would be very high, while the redeeming feature of using the exhaust steam, as originally designed for heating vats would be wholly absent with compressed air as a driving agent. In order to produce greater economy it was decided to use that type of Mesta pickler which balances practically all dead loads by force without mass. Attempts to balance the dead weights of Mesta pickling machines are quite numerous, but in any cases where balancing had been done by counterweights, the result was disastrous on account of the mass of the counterweight. It must not be forgotten that on the down stroke, unbalanced weight is the only moving force. If the unbalanced weight is cut down to one-quarter by the addition of counterweights, then the resulting downward acceleration will only be one-seventh of what it was before the addition of the counterweights, because the force will be only one-quarter of what it was before, while the mass which is to be moved is 75 per cent greater than before. Naturally all of these attempts resulted in excessive sluggishness of operation and were sooner or later

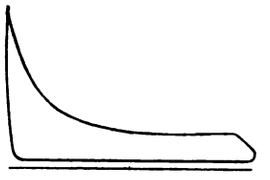

Fig. 2.

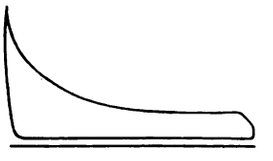

Fig. 3.

Indicator cards from pickling machine operated by compressed air. Indicator cards for full load.

discarded. The Mesta Machine Company, several years ago, solved this problem by using compressed air for balancing purposes because compressed air furnishes a force of practically no mass. It will be remembered that the modern type pickling machines have bottom piston rods for the purpose of properly supporting the overhead spider and crates without any wear in the steam cylinder. In the latest designs, the cross-sectional area of the bottom piston rod has been used to float on compressed air, the deadweight of the plunger with its piston, together with a large part of the weight of the spider. By doing so the operating piston is relieved of lifting the dead load of the parts mentioned at every stroke and much greater economy of steam and air is obtained. It is to be noted from the illustration, Fig. 1, that the steel casing which surrounds the bottom piston rod is buried in concrete and holds the whole machine rigidly, even if no foundation bolts are used.

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In order to test the economy of operation of a machine of this late type, a test was made to determine the air consumption for various loads on the machine. During the test due attention was also paid to the action of the machine, and observations were made with regard to the question whether, in spite of the balancing, the machine would have the same speed of operation. In designing this air operated machine, changes were made in the ports and valves to preserve this quick action of the machine. It is to be added that this characteristic feature was found to be as predominant as in the steam operated machine. Pressure readings were obtained by passing the air through a high pressure air meter, which had just been calibrated. In addition to the meter readings, the air consumption was also computed from indicator cards. The latter quantity was regularly smaller than the quantity recorded by the meter, which is natural, since there are slight air leakages in the machine. The meter readings may therefore be considered reliable. Fig. 2 shows an indicator card from the machine with two loaded crates, while Fig. 3 is an indicator card from the machine with one loaded crate. It will readily be seen that there is considerable expansion of the air used in the machine and for that reason, the air is used with a fair degree of economy. When operated with two loaded crates, the machine used 20.7 cubic feet of compressed air per minute while running 32 strokes per minute. While loaded with one crate, the machine used 19.6 cubic feet of compressed air per minute while running 30 strokes per minute. In the former case, the air gauge pressure at the machine was 87.1 pounds per square inch, whereas in the latter case it was 82 pounds per square inch.

In the test with two loaded crates, the indicated horse power of the machine was 6.06 hp, while the ideal hp which might have been obtained from the compressed air by expanding it without any loss for the atmosphere would have been 13.8 hp. To those who have studied the efficiency or rather the inefficiency of power transmission by compressed air, this will present itself as a remarkably good result. The Mesta steam pickling machine uses approximately 35 boiler hp. From the comparison, it is evident that the introduction of the balancing feature has made the use of compressed air on pickling machines a complete success from the standpoint of economy.

It is quite possible that the growing electrification of rolling mills may frequently present circumstances similar to those existing at the Consolidated Metal Company and for that reason the tests of the machine operated by compressed air will be of interest.

Blue Water Gas as a Metallurgical Fuel

Approximate Cost of Twin Blue Water-gas Sets With a Daily Capacity of Twenty-five Million Cubic Feet—Cost of Blue Water-gas Vs. Producer Gas Per Million Btu.

By A. E. BLAKE.

A paper entitled "Some Considerations With Regard to Fuel Gas," was read before the Engineers Society of Pennsylvania, by Prof. Fred Crabtree, some time ago, an abstract of which appeared on page 237 of the May issue of THE BLAST FURNACE AND STEEL PLANT. A. E. Blake's discussion of this paper in which he gives cost figures concerning blue water gas installation follows.

In coming to the Pittsburgh district to talk about burning gases I soon found, especially in connection with large projected plants, that blue water gas is almost unknown. A good many inquired what the stuff was; but I think it is much better known now by those particular engineers.

The following gives the approximate cost of six 11-foot twin blue water-gas sets with daily capacity of 25,000,000 cubic feet (one set idle); also the cost of blue water-gas vs. producer gas per 1,000,000 Btu.

The estimate on the blue water-gas installation is based on prices of about September 1, 1918.

Your attention is particularly called to the advantages of the blue water-gas plant with central location, all materials being handled at one point, delivering a clean and practically dry gas of uniform quality at the condenser outlet. This gas can be delivered to any point with low distribution cost.

The producer-gas plant (bituminous coal), to insure clean product, will require the necessary scrubbing and preheating apparatus, and furnishing the same total heat as the blue water-gas plant would require installation of producers at various locations with necessary facilities for handling material at different points.

The producer-gas plant will need adequate steam plant for furnishing the required steam, with fuel storage and auxiliary apparatus for handling materials; whereas the blue-gas plant, with utilization of the waste-heat boilers, will supply 90 per cent of the steam required.

Approximate Estimate for Blue-Gas Plant, Pittsburgh District. Six 11-Foot Twin Sets, With Waste-Heat Boilers.

Generators, castings, etc.:	
Twelve sets generators	$ 32,000
Twelve sets grates and hold-up bars	5,500
Combustion chambers:	
Six 10′ 6″ by 16′ 3″ combustion chambers and castings	10,000
Loose castings	500
Reverse steam connections	13,000
Valves	5,000
Linings	84,000

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Hydraulic operation	18,000
Machinery:	
Four 35,000 ft., 40" pressure, turbine blowers at $9,000 erected	36,000
Blast mains	20,000
Scrubbers and seal pots	25,000
Take off mains	10,000
Piping, 4 by 8,000	32,000
Air and steam controls, 4 by 1,500	6,000
Specials, 4 by 900	3,000
Operating floor, 16,000 square feet at $2	32,000
Scrubber valves and connections	10,000
Miscellaneous:	
Drawing	3,000
Inspection	1,000
Freight, etc.	6,000
Handling charges	1,500
Local material	2,900
Field engineering	6,000
Erection labor	9,000
Liability insurance	1,000
Final inspection	200
Operating expenses	2,500
Boiler makers expense	3,000
Tracing material	1,500
Expediting	1,500
Premium on castings	15,000
	$396,500
Contingencies, 10 per cent	39,650
	$436,150
Waste heat boilers:	
Six sets structural steel supports (not to exceed 40,000 pounds) 240,000 pounds at 8 cents	$ 19,200
Boilers.	
Six 9' 6" boilers, 350 four inch tubes, etc., at $12,000	72,000
Castings at 500 (no retarders)	3,000
Washers and castings at 2,000	12,000
Steel connections, combustion chambers to boilers, 24,000 pounds at 8 cents	1,920
Stacks, platforms, connections and castings, 2 by 1.5 or 3 by 6,865	20,605
Coverings, 3 by 1,500	4,500
Linings, 3 by 3,000	9,000
Soot blowers, 6 by 100	600
Feed water heater and piping, 3,000 hp heater	7,500
Pumps	1,500
Boiler fixtures	3,600
Miscellaneous:	
Welding tubes	6,500
Bolts, nuts and washers	300
Local material	200
Drawing	2,500
Shop inspection	900
Freight and unloading	5,500
Handling charges shop	150
Erection labor	7,500
Field engineering expenses	2,000
Liability insurance and boiler policy	1,500
Boiler makers' expense	4,500
Expediting in shop	1,000
Tracing material	500
Premium of castings	3,500
	$192,475
Contingencies, 10 per cent	19,248
	$211,723
One 1,000,000 cu. ft., 3 lift holder 125' diameter	110,000
Two pushers, 20,000 cu. ft. 30" pressure at $15,000	30,000
Six 8' 6" by 22' 0" condensers, seal pots, connections, etc.	48,000
Yard connections	15,000
	$850,873
Engineering fees and overhead, 15 per cent	127,631
Total	$985,504
Interest, 6 per cent	$59,130
Depreciation, 3 per cent	29,565
	$88,695

Gas made (365 days) 9,125,000 M—0.97 cents per 1,000 feet or 0.97 cents by 3,226 cu. ft.—3.12 cents per 1,000,000 Btu.
Operating cost 28.91 cents per 1,000,000 Btu.

32.03 cents per 1,000,000 Btu total cost including interest and depreciation.

Blue Water Gas Plant Daily Capacity (5,000,000 Cubic Feet Per Set) Six Sets 11' 0" Twins (5 Operating)

Capacity of plant per day ..... 25,000,000 cu. ft.
Gas made per ton fuel ..... 54,000,000 cu. ft.
Btu delivered per ton fuel (310 Btu per cu. ft.) 16,740,000
Steam in addition to waste-heat, boiler, per ton .. 540 pounds

Cost Per 1,000 Cubic Feet.

	No. men	Shifts	Total men	Daily rate	Amt.	Total	Cost per 1,000 cu. ft. in cents
Supervision:							
Superintendent	1			20	20		
Asst. Supt.	1			10	10		
Night Supt.	1			8	8	38.00	0.155
Boiler labor:							
(300 hp.)	2	3	6	4	4	24.00	0.100
General house labor							
Gas makers	5	3	15	5	75		
Helpers	5	3	15	4	60	303.00	1.211
Clinkers	12	3	36	4	144		
Screening ashes	2	3	6	4	24		
General labor:							
Engineers	1	3	3	5	15		
Condensers, etc.	1	3	3	3	5	30.00	0.120
Mechanics:							
Machinist	1		1	6	6		
Blacksmith	1		1	6	6		
Fitter	1		1	6	6	30.00	0.120
Helpers	3		3	4	12		

Power water, etc.	0.100
Repairs to apparatus	1.200
Repairs to buildings	0.100
Boiler fuel, 10 lbs. steam per 1,000 cu.ft. at $2.50 ton coal	0.156
Generator fuel, 38 lbs. per 1,000 cu. ft. at $3 ton coal	5.700
	8.962

1,000 cu. ft. blue gas (310,000 Btu) 3.226 cu. ft. per 1,000,000
8.962 × 3.226 = 28.91 cents per 1,000,000 Btu.

Producer-Gas Plant (24 Tons Coal Per Producer) (20 Producers, 18 Operating)

Capacity of plant per day ..... 430 tons standard gas coal
Gas made per ton of fuel ..... 120,000 cu. ft
Btu delivered per ton of fuel 18,000,000
Steam required per ton of fuel ..... 2,540 pounds

Cost Per Ton of Coal Gasified.

	No. men	Shifts	Total men	Daily rate	Amt.	Total	Per ton gassif'd
Superintendent	1		1	20	20		
Asst. Supt.	1		1	10	10	38.00	0.090
Night Supt.	1		1	8	8		
Boiler labor:							
(1,000 hp.)	4	3	12	4	48	48.00	0.112
Producer labor:							
Gas maker	4	3	12	5	60		
Helpers	6	3	18	4	72	180.00	0.419
Ash men	4	3	12	4	48		
Mechanics:							
Machinists	1		1	6	6		
Blacksmith	1		1	6	6	30.00	0.070
Fitters	1		1	6	6		
Helpers	3		3	4	12		

Power, water, etc.	0.058
Repairs to apparatus	0.480
Repairs to buildings	0.064
Boiler fuel, 2,240 lbs. per ton at $2.50	0.380
Gas coal, 1 ton at $3.25	3.250
	4.923

One ton of coal (120,000 cu. ft., 150 Btu.) = 18,000,000 Btu
4.923 ÷ 18 = 27.35 cents per 1,000,000 Btu.

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Reducing Non-Metallic Impurities in Steel

Selection of Runner Bricks, Temperature Control and Rate of Pouring Essential—Residual Manganese for Reducing Sonims. Recommends First Quality Bricks for Ladle Lining.

By L. B. LINDEMUTH.

The following is a discussion of a paper entitled "Present States of Non-Metallic Impurities of Steel," read by Henry D. Hibbard before the May meeting of the American Iron and Steel Institute. Mr. Hibbard referred to the introduction of non-metallic impurities from sources foreign to materials entering into the metallurgical reactions. These sources would include brick, silica, sand, ganister, loam, fireclay, furnace bottom material, dirt from the moulds and stools, mould wash or non-metallic ingredients from any other similar source. The composition of such impurities consist of silica, oxides and silicates of aluminum, iron, manganese, lime and magnesia, and all manner of complex silicates of any one or combinations of all. These silicates in turn are capable of combining with sonims produced by reactions in the steel. With such combinations it is difficult, or I might say impossible, to determine which or how much of these non-metallic impurities are produced by materials used for the metallurgical reactions or by materials coming from outside sources.

There is much evidence which shows that materials from outside sources are present in steel in more or less large amounts. A rough average of the life of a ladle lining indicates that the equivalent of 0.3 per cent of the weight of the heat in brick work is removed from the ladle lining each time a heat is tapped into it. For a 100-ton heat 672 pounds of brickwork and clay enters into the steel and slag. No doubt a large portion of this enters the slag, but further evidence shows that some of it is caught in the steel.

It is the practice in some plants to use sand around the nozzle to prevent a leak while tapping. This sand or a large portion of it, is washed into the first part of the heat while the steel is being poured. The nozzle and sleeve bricks wear away appreciably, both by fusion and abrasion, and these particles are necessarily churned up with the steel in pouring. Where steel is poured through boxes or tun dishes the same action of fusion and abrasion takes place with the lining and nozzles of the boxes. As slag is not present in the box, it necessarily follows that the brick and clay enters the moulds with the steel. Similarly, in bottom pouring, where steel passes through firebrick runners and enters the bottom of the moulds, the runners are fused or abraided and the particles of fused clay must pass into the moulds from the bottom. The advantage of good surface conditions gained by this method of pouring is possibly offset by the liability of a greater number of inclusions. This would seem particularly true where comparatively long ingots are cast. Some plants, in bottom pouring, have produced steel for ordnance exceptionally free from sonims by the proper selection of runner bricks, careful temperature control, rate of pouring and possibly by a mould designed to prevent corner weaknesses which are sometimes associated sonims, and by pouring a comparatively short ingot. The advisability of top or bottom pouring, and the conditions which would require one or the other for producing steel more free from sonims is still undetermined. A general rule applicable to one plant cannot necessarily be applied to others until further observations develop some definite knowledge about this much disputed subject. It is common practice in many plants where ingots are top poured to wash the stools with a clay or lime wash. That stools are worn away by the force of metal striking them is further indication that whatever material was used for this wash will, in part, be mixed up with steel in the moulds. It is further common practice to wash moulds with a mixture of graphite and water or graphite and molasses or tar, or some other binding substances. The graphite commonly employed contains about 50 per cent ash which is an iron aluminum silicate. When fused under reducing or neutral conditions this ash is green and crystalline similar to inclusions which I have often seen, and its position in the moulds is particularly favorable for its entanglement near the surface of the ingot. Furnace slag may be introduced into the steel by having slag from the previous heat adhering to the sides and bottom of the ladle. As the entire surface of the ladle is more or less fused away this furnace slag will of course be similarly fused. The fusion or abrasion of furnace runner brick ganister and clay, and loam if used, in the runners, the abrasion of furnace bottom, particularly where bottoms have been built up from lime and previous slags, rusty moulds and steels, asbestos, packing, etc., can be other possible sources for the introduction of oxides and silicates into the steel. It is problematical what proportion of impurities so introduced will float to the surface and also what conditions will best promote this floating.

It is generally conceded by all investigators, and practical results bear out the contention, that in the manufacture of steel an appreciable percentage of residual manganese throughout the making of the heat is of the greatest benefit in reducing sonims, which I might designate as being of metallurgical origin, and producing steel with the best rolling or forging qualities.

If we were to overlook the fact that non-metallic inclusions can occur from the sources outside of the steel which I have just enumerated then the general assumption that steel should be poured hot for the elimination of sonims would probably be correct, but

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the fusion of bricks, abrasion of furnace bottom and cutting of steels and perhaps moulds is increased by an increasing temperature so that by choosing conditions which will better one side of the equation we have produced an effect which increases the tendency for inclusions from another source. It might be of advantage to have the steel in the furnace at some stage of the process, above normal temperature, but allow it to cool in the furnace before tapping.

Outside of the question of inclusions the question of pouring steel at a temperature above normal increases the difficulties encountered from crystallization known under the general term of "ingotism." To recommend pouring steel at higher temperatures without the knowledge of the proportion of sonims introduced from outside sources, and without considering ingotism, might lead to the elimination of one class of impurities but reduce the quality of the steel by introducing other defects just as harmful, from a source caused by the high temperature. I think it will be conceded that generally the best results are obtained by pouring steel on the cool side rather than the reverse.

Fused firebrick or fireclay and unfused grains of silica sand are trapped and held in steel even under conditions which we would think would be most favorable to their floating to the top, namely, in skulls from the bottom of ladles. Here solidification takes place slowly compared to solidification in moulds, but I have seen in many of these ladle skulls, several inches from the surface, grains of unfused sand, light bottle green slags, transparent amber color slags, dark green opaque slags and portions of fused bricks from the ladle lining either imbedded in the solid steel or entangled in fir tree crystals.

The flash or fir from the bottom of an ingot which freezes instantly often shows an inclusion of fused material of considerable size.

In another investigation I had analyzed, from ingots of acid open hearth gun steel, slags which collected on the outside surface of ingots about one-third the distance from the bottom and also from the same ingots slag which had collected on the top. The average of these slags analyzed as follows:

	Slag ⅓ from bottom, dark greenish transparent	Slag from top surface, bottle green transparent
SiO_2	56.38	49.35
FeO	6.78	4.75
MnO	17.72	29.59
Al_2O_3	15.33	12.89
CaO	1.39	0.89
MgO	1.90	2.28

To these heats no aluminum was added either in the ladle or moulds. The increase in manganese oxide from 17.72 per cent to 29.59 per cent substantiates the statement that silicates will react with the manganese of the steel, and the alumina indicates that these slags were of clay origin. I am unable to account for the presence of lime and magnesia unless it could come from slag left in a ladle which had previously been used for basic steel. In other cases of large forging ingots from 30 to 40 inches in diameter, grains of sand, bottle green, transparent inclusions and blue green aluminum silicates have been encountered in comparatively large sizes 8 to 10 inches from the surface of the ingot and located anywhere in the bottom half of the ingot.

Whether or not agitation of the metal helps remove sonims is also a question which is problematical. It is reasonable to expect that if we find inclusions in all parts of ingots of a size visible to the naked eye, which should be the ones most likely to float to the top, microscopic inclusions and those of molecular size can exist to an even greater extent under the same conditions. If such is the case agitation such as occurs in "rimmed" steel, or as is designated by Mr. Hibbard "effervescing" steel, would tend to keep these small particles in circulation and therefore prevent their rising to the surface. It is also questionable whether quiet or dead steel solidifies more quickly than rimmed steel. Our knowledge on the subject would indicate that rimmed steel would solidify more quickly than dead steel and that solidification takes place very rapidly after the rimming has ceased. If such is the case the sonims which have been circulating by the rimming action would be more quickly caught in the freezing steel than if the steel had quietly solidified. There have recently come to my attention hundreds of tons of soft basic open hearth rimmed steel, bottom poured, which contained enormous quantities of inclusions of large sizes analyzing from 52.0 to 60.0 per cent $Si_2\ O_3$ — 5.0 to 7.0 per cent, FeO — 2.0 to 7.0 per cent, MnO and over 20.0 per cent $A1_2O_3$. Some of those inclusions showed the unaltered structure of fused firebrick or clay. On the other hand, in the case of dead steel the growth of the fir tree crystals with their network of branches would tend to catch such particles as would ordinarily rise to the surface if their progress was uninterrupted. These fir tree crystals, sometimes 12 inches or more in length, extend into the molten steel and undoubtedly form a serious obstacle to the floating of sonims. The corners of ingots afford numerous examples of non-metallic particles being so entrapped.

Mr. Hibbard's statement that scum collects on the top of rimmed steel but does not collect on the top of dead steel does not always hold true. Manufacturers of rails and other dead steels, whose practice is to make ingots with convex tops, realize that this cannot be accomplished unless particles of slag or scum which have collected on the top are immediately removed. It is true that in many cases this scum does not appear on the top surface of the ingot when making dead steel but it is almost invariably found in the pipe cavity, showing that it has floated to the top of the liquid metal after the top surface has solidified.

Whether or not there is a larger collection of sonims on the top of rimmed steel or dead steel is very questionable, although from general observation I would say that the quantity of scum visible on the top of rimmed steel is greater than that which is encountered in the pipe cavity and on the top of dead steel.

The crucible process is usually credited with producing steel freer from sonims than any other process, but is this to be attributed to the process or to com-

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paratively small heats and almost invariably small ingots? The ingot size I am sure has a very pronounced influence on the quantity and size of sonims which can be found, whether of internal or foreign origin.

Crucible ingots of the size ordinarily cast for tools are so small that they solidify clear through almost immediately after they are cast, thus preventing sonims of molecular sizes from agglomerating and at the same time making their distribution throughout the ingot practically uniform.

If we were to cast an ingot of say 30 inches in diameter from crucible steel at the same temperature and under the same conditions as open hearth steel, I am not sure but that sonims would be as numerous as sometimes found in steel made by other processes. There is not sufficient information to say whether the practice of the crucible process should be imitated as much as possible for the reduction of sonims.

If it is possible to reduce sonims to a minimum by furnace practice, would not the investigations of Mr. Hibbard and Dr. McCance indicate that the processes most suitable for the elimination of sonims, not considering the crucible process, are the duplex processes using a basic open hearth furnace and electric, using duplex metal or a charge of 100 per cent scrap. If in the duplex process, using a basic open hearth furnace, the steel were treated with sufficient manganese to maintain in the charge at all times an appreciable percentage, say .25 per cent of manganese, the sonims should be in a condition to float most readily, the quantity being small on account of the absence of silica or silicon and the distance for the sonims to float to the top being at a maximum 30 inches. The same conditions would exist in an electric furnace where pig iron was not used in the charge and hence no silicon introduced. Manganese in the bath would at all times be sufficient to react on the sonims and to reduce FeO in solution which would otherwise tend to form sonims during solidification. If the steel in the furnace could thus be cleared of sonims to the minimum extent practicable, a comparative measure of sonims rising from foreign sources might then be made. The converse is also true, that is if we reduce the sources of foreign impurities to a minimum we could then be in a position to study the quantiative effects of various processes, casting temperatures, etc.

It is almost universal practice to use in ladle linings and runners, bricks of third quality with regard to fusion temperature. Bricks of this quality are dense and become vitrified, therefore making it easy for the removal of steel skulls and scrap from the ladles and runners. First quality fireclay bricks steam pressed have a density probably equal to those of third quality bricks and it might therefore be advantageous to line ladles and runners with first quality bricks using a clay bond of equal quality. Loam clay, which is so frequently used in many plants, is much more fusable and more easily washed away than the third quality bricks and therefore is a probable source of more non-metallic inclusions than the bricks in plants where it is so used.

In this brief discussion I have merely tried to emphasize one phase of sonims which to my mind has not been sufficiently brought out by those who have made a study of the subject, and also to point to the exceedingly complex nature of the problem, and the comprehensive nature of observation necessary for arriving at conclusions which will be of practical value.

PRACTICAL NOTES ON PHYSICAL TESTS OF STEEL.

(Continued from page 437)

lower cross-head after the grips have been removed. The test-piece is set upon the lower block and the cross-head moving downward exerts a slow steady pressure on the specimen. The operation of the machine is the same as in the tensile test except that the machine is usually run at a slower speed due to the fact that in compression tests there is no motion lost by squeezing together of any grips. According to the specifications of the A. S. T. M. the height of the test-piece should be two and one-half times the diameter. Pieces of more than five times their diameter fail by bending. The size usually used by the author is 1.128 inches in diameter by 1 inch in height, which gives excellent comparative results, but which does not allow of a theoretically perfect fracture occuring. It does, however, save considerable of the cost in preparing the specimen. It is absolutely essential that the ends of the test-piece should be parallel to each other and perpendicular to its axis. The elastic limit in compression is usually taken as the first permanent set of .001 inch which occurs. The only way in which this can be determined is to release the load after each increment of 1,000 or 2,000 pounds and measure the height with a micrometer gauge. After the yield point is passed the load is applied as in a tensile test until either failure takes place or the piece endures the maximum load desired. If the bar stands the test without failing, the height of the piece is measured and the percentage compression computed. This test is another form of static test. It is rarely, if ever, used in testing ductile metals, but is almost always specified in instances where brittle metals must stand heavy and repeated stresses, such as bridge bearings, etc.

Transverse tests, although of relatively small importance, are usually made on cast irons. The bar is not machined, but is cast in a vertical position after a pattern tapering from 1¼ inches at the upper end to 1 3/16 inches at the lower. The ends are supported upon the apex of two wedge-shaped blocks set 12 inches apart upon the bed of the testing machine. A similar block with apex downward is fastened to the under side of the lower cross-head and upon the cross-head moving downward it exerts a force upon the center of the test-bar until rupture takes place. In some instances more ductile metals are tested transversely; but instead of testing these to failure, it is usual to specify that a certain force must be withstood without deflection passing a certain point.

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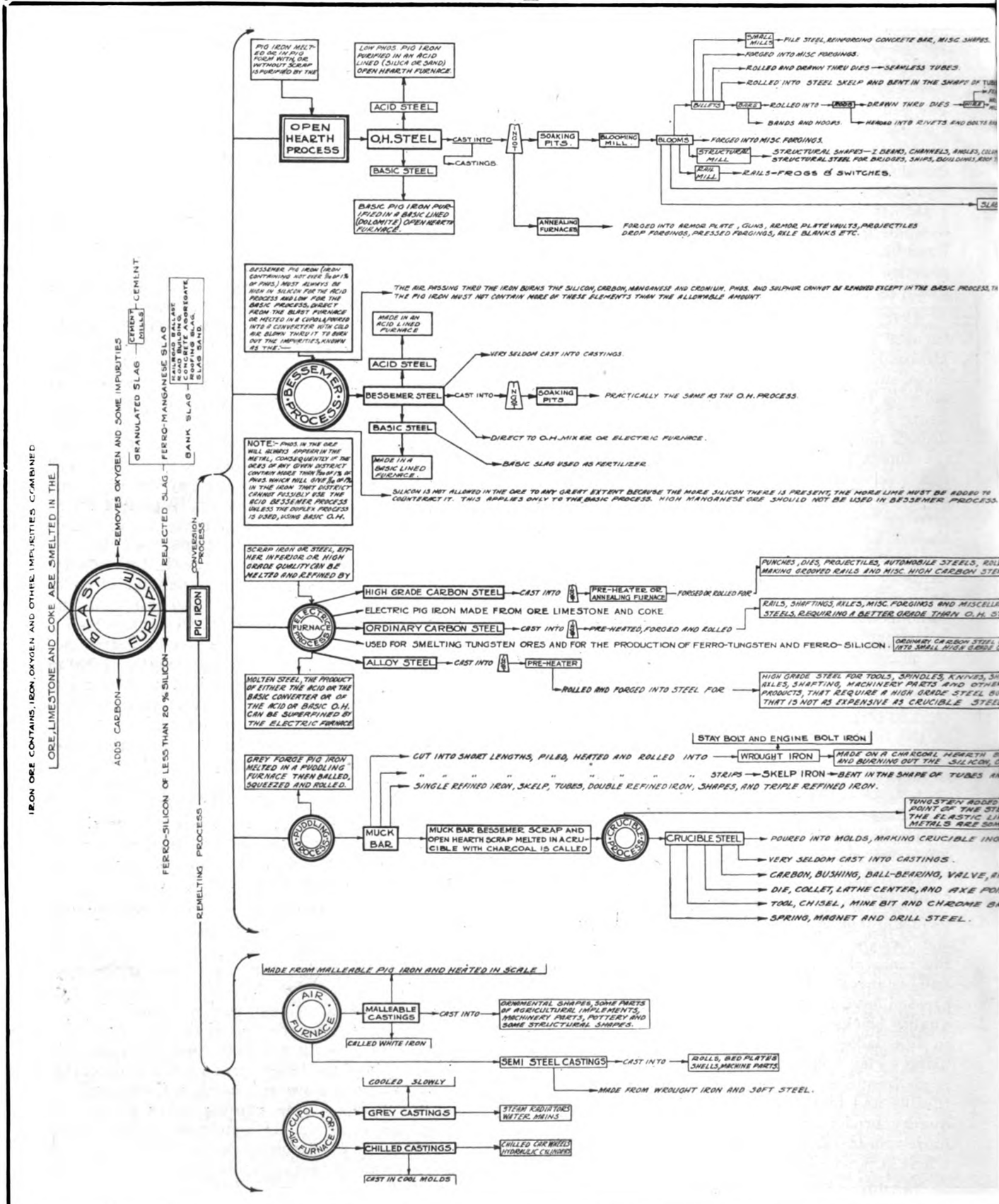
Development of Iron



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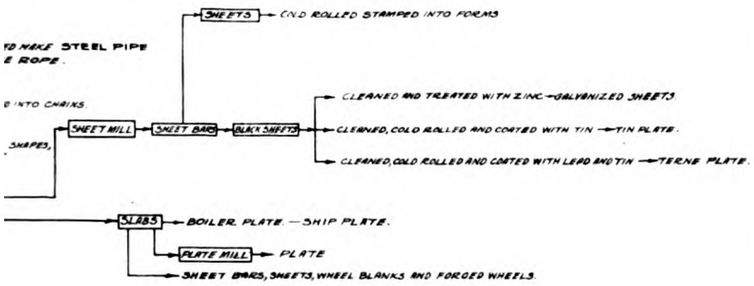
Ore into Iron and Steel



OPEN HEARTH PRODUCTS

ORDINARY STEEL, COLLET STEEL, SPRING STEEL.
SHELL " , MAGNET " , ROLL " .
NICKEL " , FREE CUTTING STEEL.
CHROME " , WELDING AND RIVET STEEL.
VANADIUM " , CASE HARDENING "
HIGH MANGANESE, FORGING AND MACHINE,
NICKEL CHROME, STRUCTURAL STEEL.
" VANADIUM, BOILER. "
CHROME TUNGSTEN, FLANGE "
NICKEL CHROME VANADIUM.
TITANIUM.

NOTES ON O.H. STEEL PRODUCTS.

ACID O.H. STEEL IS MORE RELIABLE THAN BASIC O.H. STEEL.
THE BEST STRUCTURAL STEEL FOR BRIDGES AND SHIPS IS ALWAYS MADE FROM O.H. STEEL. BOILER STEEL AND RIVET STEEL CAN BE MADE FROM EITHER O.H. OR BESSEMER STEEL. O.H. STEEL IS MORE RELIABLE AND LESS LIABLE TO BREAK IN SERVICE THAN BESSEMER STEEL OF A SIMILAR COMPOSITION.

GLOSSARY

BLOOMING MILL:— ROLLING MILL FOR ROLLING INGOTS DOWN TO BLOOMS AND MISC. SHAPES.

BLOOM:— A RECTANGULAR MASS OF METAL OVER 5" SQUARE AND OVER 5'-0" LONG.

BILLET:— A BAR 5" SQUARE OR SMALLER DRAWN DOWN FROM A BLOOM.

CASE-HARDEN:— STEEL HAVING AN EXTREMELY HARD OUTER SURFACE BUT A SOFT INTERIOR.

DOLOMITE:— A BRITTLE CALCIUM MAGNESIUM CARBONATE, OR MAGNESIUM LIMESTONE.

SCALE:— IRON OXIDE ON SURFACE OF STEEL CAUSED BY HEATING.

INGOT:— A MASS OF METAL CAST INTO MOLD FOR FURTHER HOT WORKING.

MOLD:— A FORM IN WHICH THE METAL IS CAST.

SOAKING PIT:— FURNACE USED FOR REHEATING INGOTS PREPARATORY TO ROLLING AND FORGING

PRE-HEATER:— FURNACE USED FOR REHEATING THE INGOT OR BLOOM BEFORE IT IS FORGED OR ROLLED.

SLAB MILL:— MILL FOR ROLLING INGOTS & BLOOMS INTO SLABS.

PICKLING:— REMOVING SCALE BY ACID SOLUTION.

PIPE:— SEAMS IN INGOTS, BLOOMS, BILLETS ETC.

BESSEMER PRODUCTS

STEEL SPLICE BARS AND STRUCTURAL STEEL FOR BUILDINGS CAN BE MADE FROM EITHER OPEN HEARTH OR BESSEMER STEEL. THE BEST GRADE OF BOLTS AND NUTS ARE MADE FROM BESSEMER STEEL. ALL STRUCTURAL, RAIL AND BOILER STEEL WAS AT FIRST MADE BY THE BESSEMER PROCESS BUT THE OPEN HEARTH HAS ELIMINATED MOST OF THE BESSEMER PRODUCTS.

NOTES ON THE BESSEMER PROCESS

PHOSPHOROUS ORE IS USED IN THE BASIC BESSEMER PROCESS WHILE INTERMEDIATE ORES ARE USED IN THE BASIC O.H. PROCESS. ACID BESSEMER IS MORE RELIABLE THAN BASIC BESSEMER STEEL OF A SIMILAR COMPOSITION. AS A RULE ALLOY STEEL IS NOT MADE BY THE BESS. PROCESS. THE BASIC BESSEMER PROCESS IS PRACTICALLY EXTINCT ON ACCOUNT OF THE COST OF FURNACE LININGS AND THE GRADE OF ORE REQUIRED.

GENERAL NOTES ON IRON & STEEL.

CAST IRON CAST IRON IS GENERALLY IRON CONTAINING SO MUCH CARBON (2.20% OR MORE) THAT IT IS NOT USEFULLY MALLEABLE AT ANY TEMPERATURE. SPECIFICALLY IT IS CAST IRON IN THE FORM OF CASTINGS OTHER THAN PIGS.

MALLEABLE CAST IRON IS IRON WHICH HAS BEEN CAST IN THE CONDITION OF CAST IRON AND MADE MALLEABLE BY SUBSEQUENT TREATMENT WITHOUT FUSION.

WROUGHT IRON IS SLAG BEARING MALLEABLE IRON CONTAINING SO LITTLE CARBON (0.30% OR LESS) THAT IT DOES NOT HARDEN GREATLY WHEN COOLED SUDDENLY, OR IS MEANT, THE PRODUCT OF THE PUDDLING FURNACE OR THE SINKING FIRE.

STEEL A COMPOUND OF IRON (CHIEFLY WITH CARBON) DECIDEDLY MALLEABLE AT SOME HIGH TEMPERATURE AND HARDENING QUICKLY BY SUDDEN COOLING.

SIMPLE STEEL CONSISTS CHIEFLY OF IRON, CARBON AN MANGANESE.

WELD STEEL IS SLAG-BEARING IRON, MALLEABLE AT SOME ONE RANGE OF TEMPERATURE AND CONTAINING MORE THAN .30% OF CARBON.

ALLOY STEEL CONTAINS ONE OR MORE ELEMENTS OTHER THAN CARBON IN SUFFICIENT PROPORTION TO MODIFY OR IMPROVE SUBSTANTIALLY AND POSITIVELY SOME OF ITS USEFUL PROPERTIES.

SIMPLE ALLOY STEEL CONTAINS ONE ALLOYING ELEMENT, AS SIMPLE NICKEL STEEL.

TERNARY STEEL IS ALLOY STEEL THAT CONTAINS ONE ALLOYING ELEMENT, THE TERM BEING SYNONYMOUS WITH SIMPLE ALLOY STEEL.

QUATERNARY STEEL IS ALLOY STEEL CONTAINING 2 ALLOYING ELEMENTS SUCH AS CHROMIUM VANADIUM STEEL.

COMPLEX STEEL IS AN ALLOY STEEL CONTAINING MORE THAN 2 ALLOYING ELEMENTS SUCH AS HIGH SPEED STEEL.

ALLOY-TREATED STEEL IS A SIMPLE STEEL TO WHICH ONE OR MORE ALLOYING ELEMENTS HAVE BEEN ADDED FOR CURATIVE PURPOSES BUT IN WHICH THE EXCESS OF THE ELEMENT OR ELEMENTS IS NOT ENOUGH TO MAKE IT AN ALLOY STEEL.

RAW STEEL IS STEEL AS CAST, EITHER AN INGOT OR A CASTING.

NATURAL STEEL IS STEEL IN THE CONDITION LEFT BY A HOT WORKING OPERATION AND COOLED IN THE OPEN AIR.

NORMALIZED STEEL IS A STEEL THAT HAS BEEN GIVEN A NORMALIZING HEAT TREATMENT INTENDED TO BRING ALL OF A LOT OF SAMPLES UNDER CONSIDERATION INTO THE SAME CONDITION.

ANNEALED STEEL IS STEEL THAT HAS BEEN SUBJECTED TO AN ANNEALING PROCESS.

HARDENED STEEL IS STEEL THAT HAS BEEN HARDENED BY QUENCHING FROM OR ABOVE THE HARDENING TEMPERATURE.

TEMPERED STEEL IS STEEL THAT HAS BEEN HARDENED AND SUBSEQUENTLY TEMPERED BY A SECOND LOWER HEATING.

SOFT CENTER STEEL IS HIGH CARBON STEEL POURED AROUND A COLD INGOT OF LOW CARBON STEEL, THAT IS PLACED IN THE CENTER OF AN INGOT MOLD. AFTER COOLING IT IS PICKLED, REHEATED TO A VERY HIGH TEMPERATURE AND ROLLED. IT IS USED FOR ARTICLES REQUIRING A STEEL THAT WILL WITHSTAND SHOCK SUCH AS PLOW SHARES ETC.

BLISTER STEEL IS BARS OF WROUGHT IRON ABOUT ½" THICK CONVERTED INTO HIGH CARBON STEEL, BY BEING HEATED IN CONTACT WITH CHARCOAL IN A CLOSED CHAMBER TO ABOUT 1000°C. FOR ABOUT 8 TO 11 DAYS.

COLD ROLLED STEEL IS BARS, RODS, SHEETS OR PLATES ROLLED OR DRAWN WHILE COLD INTO STEEL FOR SHAFTINGS, PISTON RODS, KEY STEEL, FINGER BARS, KNIFE BACKS, SCREW STOCK.

HIGH SILICON STEEL CANNOT BE CASE-HARDENED.

ELECTRIC FURNACE PRODUCTS

CARBON STEEL, NICKEL CHROME STEEL.
NICKEL " , " VANADIUM "
CHROME " , CHROME " "
VANADIUM " , CHROME TUNGSTEN "
TUNGSTEN " , ELECTRIC PIG IRON "
FERRO-TUNGSTEN, FERRO-SILICON STEEL.

NOTES ON ELECTRIC FURNACE PRODUCTS.

ELECTRIC STEEL IS CAST IN INVERTED MOLDS WITH EFFECTIVELY HOT TOPS TO PREVENT PIPAGE IN THE BODY OF THE INGOT ELECTRIC STEEL IS FAR SUPERIOR TO EITHER O.H. OR BESS. STEEL BUT THE MANUFACTURES CANNOT COMPETE ON A LARGE SCALE ON ACCOUNT OF THE HIGH COST OF PRODUCTION. ALL ELECTRIC FURNACES ARE OF TWO DIFFERENT TYPES, ARC AND INDUCTION AND ARE CALLED KJELLIN, HEROULT, STASSANO, GIROD & KELLER.

TYPICAL ANALYSES.

IRON ORES (NATURAL CONDITION)

BRAND	METALLIC IRON	IRON	SI	S	P	MN
ANFECAH	70.8	2.08	54.40	2.0	.011	.034	.04
DOVER	4.26	3.37	51.80	5.0	.009	.06	.54

PIG IRON

KINDS	SILICON	SULPHUR	PHOS	MANG.
MALLEABLE	1.85 TO 2.75	.108	GUARANTEED BY UNDER	—
GREY FORGE	1.75 TO 2.25	OVER .05	.40 TO .60	.50 TO .80
BESSEMER	1.75 TO 2.25	.05	.10 TO .15	.40 TO .60
HIGH PHOS.	1.75 TO 2.25	—	OVER .100	.30 TO .70

IRON CASTINGS.

GRADE.	CARBON	SILICON	SULPHUR	PHOS.	MANG.
LIGHT	3.40	2.75	.075	.750	.400
MEDIUM	3.50	1.75	.080	.550	.600
SEMI-STEEL	3.30	1.30	.075	.400	.650
MALLEABLE	2.50	.750	.070	.180	.250

WROUGHT IRON

KINDS	CARBON	SILICON	SULPHUR	PHOS	MANG
MUCK BAR	.100	.100	.052	.198	SLAG OVER .100
SKELP	.080	.040	.050	.100	.100

BILLETS AND SHEET BARS.

KINDS	CARBON	SULPHUR	PHOS	MANG
BESSEMER	.08 TO .12	.08 OR LESS	.09 TO .12	.35 TO .50
ACID O.H.	.08 TO .12	.06 OR LESS	.06 OR LESS	.35 TO .50
BASIC O.H.	.08 TO .12	.05 OR LESS	.06 OR LESS	.35 TO .45

TOOL STEEL.

KINDS	W	CR	C	S	P	SI	V
CARBON	—	—	1.10	0.30	0.15	.200	—
HIGH SPEED	18.0	3.50	5.50	0.12	TRACE	TRACE	1.00

RAILS.

KINDS	CARBON	SULPHUR	PHOS	MANG
BESSEMER	.35 TO .55	NOT OVER .200	NOT OVER .100	.70 TO .1.14
O.H.	.46 TO .75	" "	" .040	.60 TO .90

STEEL CASTINGS.

KINDS	MINIMUM PHYS. REQUIREMENTS				MAXIMUM		
	ULTIMATE STRENGTH	YIELD POINT	ELONGATION IN 2 INCHES	REDUCTION OF AREA	C	S	P
HARD	85,000	38,250	15	20	—	.06	.06
MEDIUM	70,000	31,500	18	25	—	.06	.06
SOFT	60,000	27,000	22	30	—	.05	.05

BOILER PLATE & RIVET STEEL.

COMPOSITION	FLANGE	FIRE BOX	EXTRA SOFT
PHOS NOT TO EXCEED	ACID .04 BASIC .04	ACID .04 BASIC .03	.04 .04
SULPHUR	.05	.04	.04
MANGANESE	50 TO 80	50 TO 80	50 TO 80
CARBON	.15 TO .25	.20 TO .30	.10 TO .20

STRUCTURAL STEEL FOR BLDGS.

COMPOSITION	STRUCTURAL	RIVET O.H.
PHOS MAX. BESS	.100	—
PHOS " O.H.	.060	.060
CARBON	.15 TO .250	.250 TO .450

PUDDLE & CRUCIBLE PRODUCTS

WROUGHT & SKELP IRON, MUCK BAR.
CARBON, NICKEL AND CHROME STEEL.
VANADIUM AND NICKEL VANADIUM "
TUNGSTEN AND CHROME TUNGSTEN "
NICKEL CHROME & CHROME VANADIUM "
" " VANADIUM & HIGH SPEED.
CHROME TUNGSTEN VANADIUM.

NOTES ON THE PUDDLE & CRUCIBLE PROCESS

ON ACCOUNT OF THE EXTREME HIGH COST OF PUDDLE IRON, THE PUDDLING FURNACES ARE NOT PRODUCING 50% OF THEIR OUTPUT OF 10 YEARS AGO. CRUCIBLE STEEL IS THE BEST AS WELL AS THE MOST EXPENSIVE STEEL MADE. VERY FEW INOVATIONS HAVE BEEN ADDED TO THE ORIGINAL, SLOW AND CRUDE LIKE METHOD OF MANUFACTURE.

IRON IN CONTACT WITH IRON ORE
AS LEAVING THE METALLIC ORE.
O IRON PIPE. IRON BOILER TUBES.

T TEMPERATURE, AT WHICH IT SOFTENS AND TO LOWER THE FUSION. AND VANADIUM ARE ADDED TO GIVE TOUGHNESS. NICKEL INCREASES INCREASES THE RED HARDNESS. TITANIUM, ALUMINUM AND OTHER TO TO IMPROVE THE QUALITY OF THE STEEL.

→ HIGH SPEED STEEL

→ STEELS FOR SPECIAL TOOLS, REAMERS, DRILLS, THREADING DIES, SHEAR BLOMS, CHISELS, SAWS FOR CUTTING STEEL, PUNCHES AND STEEL FOR SOME PARTS OF ELECTRICAL INSTRUMENTS.

EATED AND ROLLED INTO BARS AND PLATES → SAWS.

DE FILE STEEL.

EL.

CUPOLA & AIR FURNACE PRODUCTS

GREY CASTINGS
CHILLED CASTINGS
MALLEABLE CASTINGS
SEMI-STEEL CASTINGS
CAST-IRON CASTINGS

NOTE: FOUNDRY PIG IRON MELTED IN A CUPOLA AND CAST INTO MOLDS MAKE IRON CASTINGS. PIG IRON MELTED IN A CUPOLA OR AIR FURNACE CAST INTO MOLDS OF EITHER BAKED SAND (OVEN DRIED) OR GREEN SAND (MOIST UNDRIED) OR SOMETIMES OF IRON COVERED WITH A REFRACTORY COATING, TO PROTECT IT FROM BEING MELTED OR OVERHEATED, BY THE MOLTEN CAST IRON, MAKE GREY AND CHILLED CASTINGS.

LARGER CHARTS AVAILABLE

This chart showing the development of iron ore and into iron and steel, including the glossary, general notes, analyses and explanations is without a question, one of the best charts of this nature available. The chart was developed by S. C. Dickerhoff, Jr., Bethlehem, Pa., and is copyrighted by him. Large blue print reproductions 30 x 50", and small black and white prints 15 x 25", can be secured for a nominal charge from Mr. Dickerhoff.

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Overfired Car Type Annealing Furnace

Description of an Overfired Furnace With Auxiliary Burners Near the Hearth Level, Used to Make Possible the Horizontal Annealing of Large Steel Cylinders.

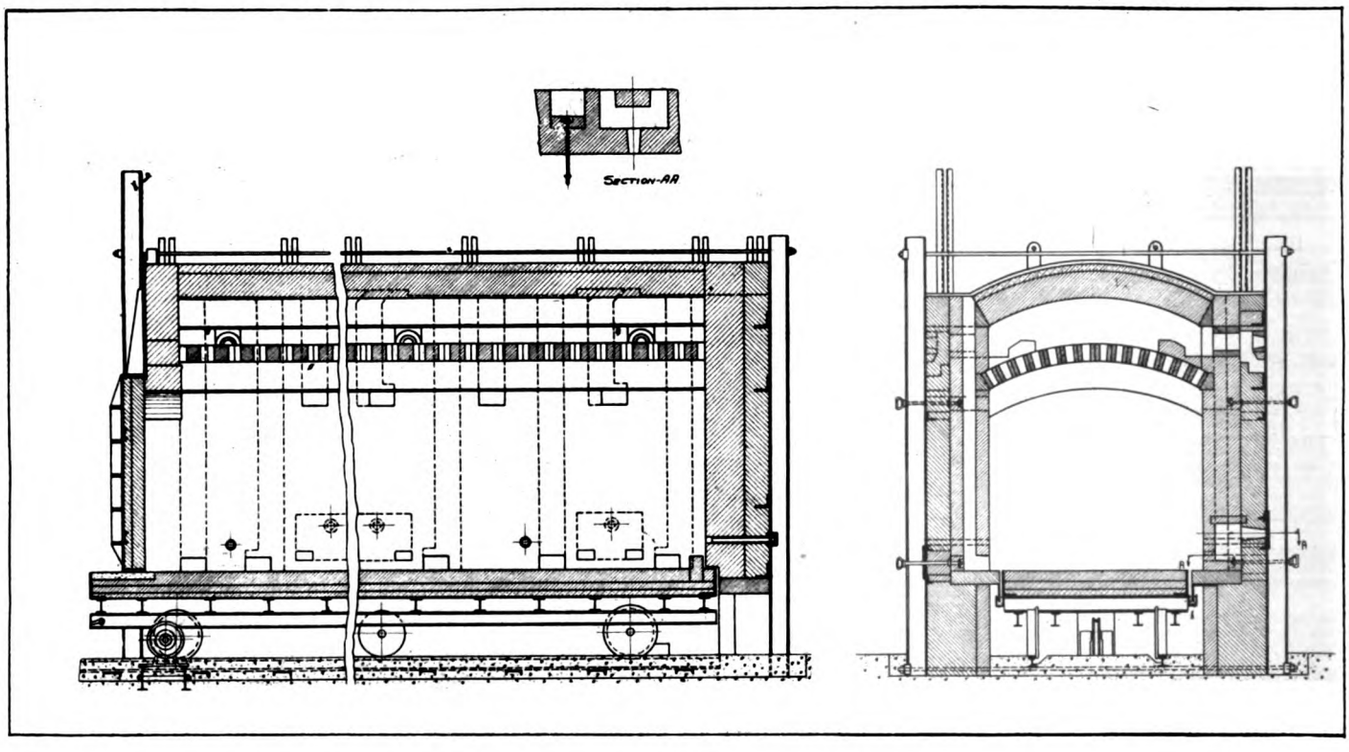
It is conventional in annealing furnace practice, to have one general source of heat. In the side-fired furnace, heat is generated on one side (occasionally on both sides), near the arch skew; under the hearth in the underfired type, and at the top of the heating chamber in the overfired type. In these more common types of furnaces for annealing, it is well known that the greater part of the heat transferred to the work to be annealed, takes place from the radiance of the flame, or radiance reflected from incandescent brick surfaces; only a small amount being transferred by convection, the hot gases being in contact with the work only momentarily; and a relatively small amount by conduction, at most only a small proportion of area of the treated piece being in contact with heated furnace temperatures that are at a temperature as high or higher than the annealing temperature of the work, which is the only condition under which transfer can take place by conduction. With relatively small pieces a sufficient surface area "Sees," the planes of radiance and to secure an even temperature throughout the work the conductivity of the metal must be counted upon as a factor which will produce an even temperature throughout the work.

A large majority of the overfired furnaces are built with movable car bottoms, which offer a great advantage over any other method, in the economical handling of large pieces in and out of the heated space, also the overfired furnace has long been recognized to give extremely economical results in the heat treating of solid steels, as much of the heat is converted to radiance and the construction of the furnace permits maximum advantage being taken of the radiance in heating. One of the large steel plants, manufacturing quantities of ordnance, had the problem confronting them of bringing a forging, approximately 4′ 6″ in diameter outside, 3′ 2″ inside diameter, to an annealing temperature of 1,600 degrees F., and afterward normalizing the piece at approximately 1,200 degrees. The chemical limitations prevented these pieces being annealed in a furnace of the vertical type, and owing to the inherent general advantages of the overfired furnace, it was decided that this type would be used. A standard overfired furnace was installed with the following general cross-sectional dimensions:

Door width	6′ 2¼″
Floor of car to top of arch	5′ 3 ″

The furnace is of ample length to accommodate the forging in question. The furnace was put in operation,

(Continued on page 459)



Tate-Jones overfired car type annealing furnace.

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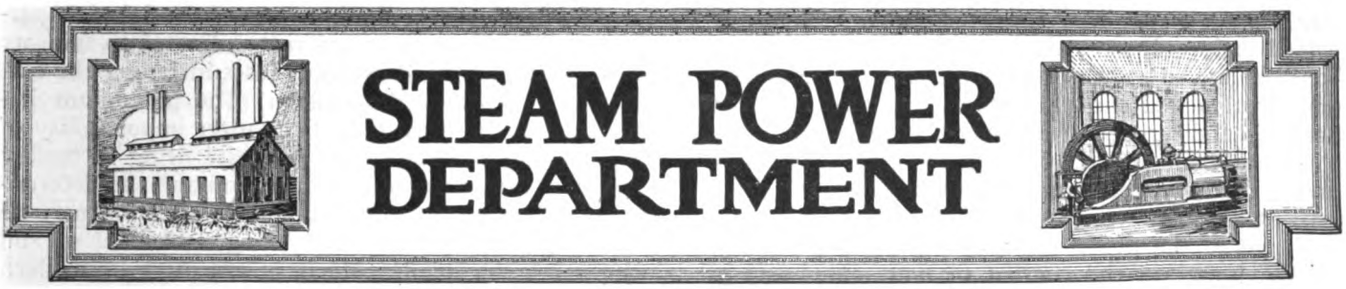

Burning Pulverized Coal Under the Boiler

Possibilities of Pulverized Fuel for Stationary Boilers. Tables Showing Results of Tests on Pulverized Fuel Plants and Data Regarding Boiler Installations.

By FREDERICK A. SCHEFFLER and H. G. BARNHURST.

The purpose of this paper is to present the facts which indicate the coming general adoption of pulverized coal as a fuel for boilers. The discussion is presented in the form of a comparison with stoker firing, the latter being the most efficient method in general use for burning solid fuel under boilers.

The ultimate adoption of a new method depends entirely on its overall commercial efficiency. In the generation of power, overall efficiency may be considered as composed of the following factors: Reliability, cost and adaptability. A method may acquire a wide field if it shows improvement in any one or two of these points. Improvement in all three points leads to the general superseding of other methods.

It is the purpose of this paper to present those facts which the authors believe indicate the coming general adoption of pulverized coal as a fuel for boilers. Since stoker firing is the most efficient method when solid fuels are used, a comparison of stoker and pulverized-fuel plants is given, with particular reference to reliability, cost, adaptability and efficiency.

Let us compare the reliability of a pulverized-coal installation with that of stokers. This factor depends on two items: Apparatus for preparing and presenting the fuel for combustion, and continuity of operation of the furnace itself. In a stoker installation the first of these includes the stoker itself. Neglecting the inherent defects of any system that presents a metal mechanism to the action of high temperatures, it may be admitted readily that the stoker system is satisfactorily reliable, with respect to its apparatus, for preparing and presenting the coal for combustion.

The corresponding mechanisms for pulverized fuel are equally reliable. This fact is proved by their widespread use for years in the cement industry and more recently in an ever-increasing variety of industries. It should be recognized that these mechanisms are not innovations, but are the result of years of development under operating conditions. Proper design of equipment by engineers of standing who are specialists in this line has made negligible the danger of dust explosions, the occasional occurrences of which in years past have furnished ammunition to the opponents of pulverized fuel.

The second condition for reliability is the continuity of operation of the furnace. Here again we find an apparent balance between stoker and pulverized-fuel installations during operation. The advantage lies with pulverized fuel, however, for several reasons. The mechanism is altogether outside the furnace, hence cleaning and adjustment and the making of the few repairs required need not interrupt the operation of the boiler. In case of sudden necessity the fire may be ignited and quickly brought to full intensity, or it may be extinguished almost instantly. Greater uniformity of flame and temperature is conducive to longer life of the furnace lining in a properly designed furnace, and to the minimum variation in furnace efficiency. Finally, the pulverized-fuel installation relieves the power plant from dependence upon the availability of a certain grade of coal. Stokers will not handle all grades of coal.

This second factor refers to the cost per Btu delivered to the boiler. The various items entering into this cost by the stoker system comprise power, repairs and maintenance, labor, interest on invest-

Abstract of paper read at the spring meeting, Detroit, Mich., June, 1919, of the American Society of Mechanical Engineers.

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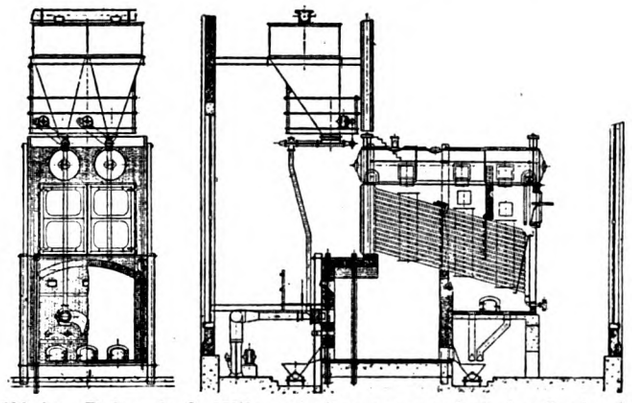
ment, depreciation, insurance and taxes. With pulverized-coal equipment the cost of fuel for the drier should be added to the preceding items. A moment's consideration will show that this item must be taken care of in the furnace of a stoker-fired boiler and that it is clearly cheaper to remove the excess moisture content from the coal in a drier, from which the gases leave at very low temperature, than in the furnace itself, where the evaporation of the moisture damps the fire, increases the content of inert gases and at the same time carries off a very perceptible amount of heat.

Returning to the balanced cost items, it appears that these show a saving in favor of pulverized fuel in a large power plant and for the stoker in a small power plant. The figures in question are discussed further on in detail. It should be noted that when central pulverizing plants are built, they will relieve small power plants of the necessity for maintaining pulverizing equipment and make pulverized fuel con-



500 hp. Babcock & Wilcox boiler arranged to be fired with pulverized coal.

siderably cheaper than stoker-fed fuel, regardless of the size of installation. This feature is already being carried out successfully.

The final factor of the cost, furnace efficiency, which governs all the others, results in all respects to the advantage of pulverized fuel for the following reasons: First—No excess air is required for complete combustion. Second—In pulverized form all of the combustible is burned, a consummation certainly impossible in lump-coal firing by either hand or stoker. Third—With pulverized fuel there are no standby losses with change of load or when shutting down, such as banked fires, etc. Fourth—With properly designed pulverized-fuel apparatus nothing of a mechanical nature takes place in the furnace.

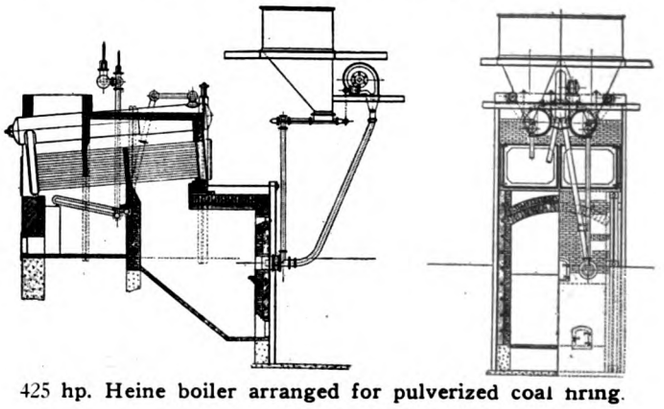
Let us now consider the third factor of overall efficiency, which is adaptability. Pulverized fuel is here preeminent. The primary feature is the possibility of burning all grades of fuel without affecting the efficiency of the furnace. To burn anthracite and very low grades of fuel requires a furnace allowing a return flow of the flame past the incoming flame, to heat up the incoming fuel, and in a furnace of this type fuel containing over 50 per cent ash has been burned with high efficiency.

The flexibility in the use of pulverized fuel is perfect, and the fire may be instantly adjusted to suit any condition of overload or lower load, including the cutting in and out of the boilers. The paramount importance of this feature and the utter impossibility of approaching it with stoker or grate firing is readily evident. Furthermore, the operation and the determination of conditions for complete combustion may be made automatic, the result being a smokeless and sootless boiler plant, which is essential in modern cities.

Furnace Design.

A few words on the design of furnaces for pulverized fuel may be of interest. The primary requisite for good results is to maintain low velocities in the furnace. The combustion is no less perfect with high velocities, but this will result in damage to the linings and in their erosion. A furnace cubical in shape usually gives the most satisfactory results.

The burners should inject the coal under low pressure and should permit of varying the density of the



425 hp. Heine boiler arranged for pulverized coal firing.

mixture in the burner itself. Their location and number will depend upon the size of the boiler and rating required, and also may be varied to suit the grade of fuel. High boiler ratings such as are used in modern boiler practice can be obtained when desired, and such overratings should be predetermined and the furnace volume designed accordingly.

It will be noted that pulverized coal behaves more nearly like liquid and gas fuels than it does like lump coal and that it is in the ideal state for burning with the highest possible efficiency. It has been shown that it is superior to lump coal as regards all three factors of overall efficiency and these statements are susceptible of proof upon investigation. The novelty of the pulverized-fuel plant is rapidly beginning to disappear, and on account of the fact that all obtainable coals are apparently becoming more inferior in quality the interest in the use of pulverized fuel is very general throughout the United States and other countries.

In Table 1 will be found an itemized statement of the costs of pulverizing coal. Table 2 gives reports of a number of preliminary tests made on some of the pulverized-fuel installations now in operation. While these do not show the maximum efficiency to be expected with the further development of the art, they

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nevertheless indicate that the inherent difficulties have been solved and that at the present moment pulverized fuel is in a position to compete advantageously with any other method of burning solid fuel under boilers.

Cost of Pulverizing Coal.

The cost of pulverizing the coal is of prime importance as low costs are essential for success and are achieved when the quantity used per day of 24 hours exceeds 100 tons. The cost of pulverizing is made up of a number of items as follows: Power repairs and maintenance, coal for drying, labor, interest, depreciation, insurance and taxes.

Table 1—Cost of Delivering Pulverized Fuel to Boilers.

	100-ton plant dollars per net ton	1000-ton plant, dollars per net ton
Power at ¾ cent per kw-hr. and 17 kw-hr. per net ton	$0.1275	$0.1275
Labor at 40 cents per hr.	0.14	0.04
Drier coal at $5 per net ton delivered	0.06	0.06
Repairs	0.07	0.07
Total actual cost of pulverizing per net ton	0.3975	0.2975
Interest at 6 per cent	0.105	0.039
Depreciation	0.12	0.04
Taxes and insurance	0.035	0.013
Total cost per net ton	0.6575	0.3895

The figures depend upon local conditions, and the size and general arrangements of the entire installation.

The item of coal for drying depends directly upon the percentage of moisture and upon the price of coal. Ordinarily only from 1 to 1¼ per cent of the total amount of coal used is required for drying. Assuming coal to have an average of 7 per cent moisture as received and the cost to be $2.50 per net ton, the cost per net ton of drying the coal will be 3 cents. At $5 per net ton the cost of the drier coal will be 6 cents.

The labor item is the greatest variable in connection with the pulverizing of coal, due to the increased output that can be obtained in larger plants per man employed. It is also subject to local rates of wages. For example, assuming labor at 40 cents per hour, a plant of 100 tons daily capacity, properly designed and equipped, will require approximately 34 labor hours to prepare the fuel and deliver it to the conveyors, whereas in a plant having a daily capacity of 1,000 tons, approximately 115 labor hours are required. Therefore the labor cost would be 14 cents per net ton in a 100-ton plant, only 4 cents per net ton in a 1,000-ton plant, and as low as 2½ cents per net in a plant of 5,000 tons daily capacity.

The interest item is based on 6 per cent of the entire investment, and the cost of the pulverized-coal plant and burning equipment will of course vary considerably with the conditions under which the plant is installed. Roughly speaking, however, the actual investment will vary from $12.80 per kw output in a 5,000 kw plant down to $4.80 per kw in a 50,000 kw plant and $4.12 in a 100,000 kw plant (assuming a turbo-generator water rate of 16 pounds and continuous boiler and furnace efficiency of 75 per cent).

All these figures in relation to cost are based on the present high prices. The investment required for a 5,000 kw plant using 100 tons of pulverized coal daily is approximately $64.000 and for a 50,000 kw plant using 1,000 tons of pulverized coal daily, approximately $240,000, so that, on a basis of 6 per cent and allowing for 365 days' continuous operation, the interest item will vary from 10½ cents per net ton in a 100-ton

Table 2—Report of Preliminary Tests Made on Pulverized Fuel Plants.

Date of test	Location of plant	Duration hours	Coal used	Efficiency maintained, per cent	Btu per lb. of coal as fired	Ash, per cent	Rating, per cent
Apr. 16, 1917	Seattle, Wash.	14.5	Renton buckwheat	77	10,000	11.60	122
Dec. 4, 1917	Chanute, Kan.	5	Kansas bituminous	72	11,996	17.7	125
Dec. 12, 1917	Chanute, Kan.	5	Kansas bituminous	83.94	12,500	18.25	125
Jan. 28, 1918	Chanute, Kan.	(25 days)	Kansas bituminous	78.1	11,435	.....	100
Apr. 26, 1918	Parsons, Kan.	6	Kansas bituminous	80.3	12,900	17.49	.....
Apr. 28, 1918	Parsons, Kan.	6	Kansas bituminous	80.9	12,289	17.49	130.8
June 14, 1918	Milwaukee, Wis.	12	Illinois and Indiana screenings	83.3	10,897	15.89	117.7
Nov. 5, 1918	Lykens, Pa.	10	Lykens No. 3 buckwheat anthracite	84.2	12,530	16.92	135
Nov. 15, 1918	Lykens, Pa.	5	Lykens slush buckwheat anthracite	81.2	13,653	11.09	142
Nov. 22, 1918	Lykens, Pa.	5	Lykens slush buckwheat anthracite	85	12,753	18.04	146
Nov. 23, 1918	Lykens, Pa.	5	No. 3 buckwheat anthracite	72.7	12,530	16.91	115
Dec. 2, 1918	Lykens, Pa.	5	Lytle slush anthracite	75.3	15,420	23.92	188
Feb. 1, 1919	Seattle, Wash.	24	Issaquah screenings	78.95	11,660	14.31	126
Feb. 2, 1919	Lykens, Pa.	4	No. 3 buckwheat anthracite	78.9	13,067	14.02	177
Apr. 7, 1919	Vancouver, B. C.	4	Nanaimo slack	83.3	9,364	28.4	125
Apr. 17, 1919	Vancouver, B. C.	5	Nanaimo slack	77.1	10,050	24.3	160
Feb. 3, 1919	Lykens, Pa.	5.5	No. 3 buckwheat anthracite	78.9	12,530	14.00	.....
Sept. 24, 1918	Verde, Ariz.	(6 days)	Gallup, New Mexico	79.5	10,680	14.31	155

The power required in an up-to-date pulverized-coal plant is from 12 to 13 kw-hr per net ton of coal crushed, dried and pulverized. The additional power required for transferring the coal to the point of use and feeding it to the boilers will vary considerably, depending upon the distance transported, the size and number of the boilers, and the conditions under which they operate. The power required for this latter purpose varies between 4 and 6 kw-hr. per net ton, so that the total power for the entire process from the track and storage delivered to the boilers is 17 or 18 kw-hr per net ton. In the following paragraphs the cost of power has been assumed at ¾ cent per kw hr.

The item of repairs, including material, labor and general upkeep of the plant or maintenance, for the entire pulverizing plant and burning equipment will vary from 7 to 10 cents per net ton of coal handled.

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plant down to 3.9 cents per ton in a 1,000 ton plant.

Depreciation in a coal-pulverizing plant is usually calculated as follows: The life of the building is considered as 40 years, of the coal driers as 15 years and of the balance of the equipment as 20 years. With a 100-ton pulverized-coal plant and burning equipment the depreciation item will be approximately 12 cents per net ton, and in a plant of 1,000 tons daily capacity it will be approximately 4 cents per net ton.

Taxes and insurance are based on 2 per cent of the entire investment and for a 100-ton plant this item is approximately 3½ cents per ton and for a 1,000-ton plant, 1.3 cents per ton. Summarizing, the foregoing results show that the total cost of pulverizing and delivering pulverized coal to boilers is approximately as given in Table 1. The cost of the pulverizing equipment complete compares favorably with the stoker equipment when everything, such as coal- and ash-conveying machinery, etc., is taken into consideration, and in large plants it is considerably less.

Safety Methods Applied to the Boiler Room

Boiler Insurance and Inspection—Local Inspection and Records. Pipe Systems—Stairways and Platforms—Cast Iron Under Pressure — Non-Return Valves — Feed-Water Regulators.

By W. E. SNYDER.

The following is taken from a paper read by the author before the Engineers Society of Western Pennsylvania. The paper was entitled the "Practical Operation of Industrial Boilers," and dealt comprehensively with all phases of the subject. That part of the paper dealing with safety has been extracted and appears as follows:

Safety.

During the past few years, owing to the development of safety work in manufacturing plants, the safety features of boiler plants which are necessary to their operation, have become well standardized. There are now on record and available for easy reference a number of rules and recommendations, a large part of which the writer has aided in preparing, which cover the important points that should be given attention to provide for the proper safety of lives and property. (See Paper on "Industrial Engineering Safety" by D. S. Beyer, Proceedings Engineers Society of Western Pennsylvania, Vol. 28, pages 143-165.) It may not be amiss, however, to mention here briefly some of the most important safety features of boiler plants, keeping in mind that this discussion applies mainly to existing plants of the older type:

Boiler Insurance and Inspection—First and most important is boiler insurance, with the incidental inspection by trained boiler inspectors which always accompanies such insurance. It is perhaps unnecessary to argue in favor of boiler insurance at this time, as all large companies with which I am familiar carry it. The benefits which result from periodic inspections by men whose sole time is taken up with such work, and who in consequence acquire an experience which makes them very keen detectors of defects, are so great that they cannot be over-emphasized. While this is true of the regular inspections made by boiler insurance companies, there is an additional advantage in having the benefit of their expert advice in case a condition develops which may make it necessary to take a boiler out of service temporarily and immediately, or when it is necessary to decide whether boilers shall be repaired or replaced. These are questions upon which it is not possible to bring to bear too much expert knowledge and experience, as the risk involved in a wrong decision is out of all proportion to the mere money cost of the insurance.

Local Inspection and Records—Next in importance to the regular inspections by the inspectors of companies specializing in boiler insurance, are the local inspections which should be made by some designated engineer or experienced mechanical man connected with the operation of the boiler plant. Such inspections should be made much more frequently than the inspections of the insurance company representatives, and should cover all of the conditions of the boiler, its setting and piping, etc., which have to do with both safety and economy. That is, the inspector should be provided with suitable clothes, so that he can get into the drums and into various parts of the setting and carefully examine the riveted seams, tube connections and pipe connections, etc., with respect to safety; and also examine the interior of drums and tubes, and the outside of heating surfaces, condition of baffles, etc., with respect to economy. Examination by the local inspector covering all conditions favorable to good economy is of special importance, because the inspection by insurance company inspectors is only required to cover such matters as have to do with safety. The insurance inspector has primarily in his mind the safety of the boiler under pressure and if he calls attention to anything which has to do with economy it is mainly because of his desire to be helpful in the proper operation of the plant. For this reason the local inspector should keep in mind both safety and economy while doing his work; also, it should be an established rule that every time the local inspector makes a complete examination of a boiler and its setting, he should write a complete memorandum of his inspection, giving the date and the number of the boiler, even though there is nothing special to report. Such a memorandum is of great advantage in case an accident occurs and it becomes necessary to make a thorough investigation. Such an investigation will bring out every

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item of information, which has to do with the condition of the boiler on which the accident occurs, for years past; and if in addition to the file of reports of the insurance company's inspectors, there are the regular and complete memoranda of the local inspector's examinations, the small amount of additional work which devolves upon the local inspector in keeping such written reports of his inspections will be well repaid.

Inspection of Pipe Systems—Next in importance to the inspection of the boiler and its setting by the local inspector, should be his inspection of the feed, blow-off and steam piping systems. Such an inspection does not need to be made as often as a boiler inspection. Possibly once a year is often enough for a complete examination of piping, but such an examination should be made, and it should be made by someone who knows enough about these conditions to know when they are wrong. It should also include the different valves and their condition. In such inspections of piping we have found and removed a large number of dangerous features, such, for instance, as cast-iron sections in main steam lines and in feed line; copper bends, corroded threads on blow-off connections; 10-inch and 12-inch steam pipes with threaded end and blank flanges screwed on, so that the full steam pressure acting on the flange had to be borne by threads cut years before; thin flanges, out of all proportion to the pressure carried; flanges in which some of the holes did not coincide, and two or three bolts were left out, etc. These and various other defects, too numerous to mention, oftentimes hidden by pipe covering, are revealed by systematic inspection of piping.

Stairways and Platforms—A proper system of stairways and operating platforms, with railings and toeboards is absolutely necessary to good operation. It is not possible to make detailed suggestions in a matter of this kind, because the local conditions are different in every boiler plant. It should be kept in mind, however, that stairways are necessary for easy and quick access to the parts of the installation above the floor level, and that these stairways should be arranged so that in case of an accident it is hardly possible for a man to be trapped with no means of getting down to the floor. The platforms and walks should be planned so that all the main valves, water columns, manholes, cleaning doors, etc., are easily accessible. This is necessary, not alone from the standpoint of safety, but to insure reliability and economy in operation. If cleaning doors and manholes cannot be reached except by old wooden ladders and planks, as used to be the case, it is a foregone conclusion that the men will use them only when they cannot help it.

Cast Iron Under Pressure—Most of the older boilers were constructed with cast iron parts, such as mud-drums, headers and pipe connections. Cast iron under steam pressure is always dangerous and when, in addition, it is subject to strains due to the heating and cooling of the boiler and its connections, it is doubly so. It is not always possible to eliminate the risk incident to the use of cast iron, but it can be minimized. Cast iron or cast steel mud-drums are often dangerous elements. Wrought steel mud-drums are now made, which it is practicable to attach to older boilers, and which are entirely safe. Wrought or cast steel headers can also be used to replace cracked cast iron headers, though a broken header is not usually a serious matter like a cracked cast mud-drum. Where the flanged connections on a boiler are subject to heavy strains, such as may be due to the connection of main steam pipes, safety valves, etc., the cast iron can be replaced by cast steel. Of course it requires the use of judgment and commonsense in deciding how far to go with the replacement of cast iron in boiler plants which have been in service a number of years, as it depends on the condition and probable remaining life of the boilers and whether there is any apparent weakness. In my opinion cast mud-drums ought to go first, if there is a possibility of continuing the boilers in service for even a few years.

Non-Return Valves—Automatic or so-called non-return valves are important safety features of any boiler plant. This type of valve, together with a gate-valve placed between it and the main steam header, with proper prevention of water pockets, makes a very good and safe arrangement. The automatic valve closes in case of accident to the boiler, thereby isolating it from the remainder of the steam system. We have had dozens of instances of tube failures or header breaks which allowed a sudden drop of pressure in the boiler, and invariably this valve immediately closes. By the use of a small connecting line and pilot valve for each automatic valve it is possible to make these valves close in case of a break in the steampipe system which allows the pressure to drop, and in this way shut off every boiler, but accidents of this character are not so common as those to individual boilers, which allow a sudden pressure drop in any one boiler. The automatic valve also serves an important function, after pressure has been raised in a boiler and it is ready to be connected to the line. In this case it is necessary only to open the gate-valve in the branch pipe any time while the steam pressure is being raised in the boiler; then as soon as the pressure in the boiler is sufficiently high, the non-return valve is automatically opened by the steam pressure, and the boiler in this way placed in service. This eliminates the operation of opening by hand the valve which permits the steam being generated in the boiler to enter the main steam system; which was sometimes dangerous, due to an accumulation of condensed steam in the branch pipe forming a water-hammer when the valve is opened, and knocking the side out of the valve or a fitting. I have known serious and fatal accidents to result, due to this cause, when boilers were connected to the line, and the use of the non-return valve, as explained, avoids the necessity for a man to be on top of the boiler while it is being "cut in."

Feed-Water Regulators—Feed-water regulators are important adjuncts in the operation of boilers. The earlier types regulated in such a way that the feed valves were either shut or wide open, and they are unfavorable to good operating conditions. The most satisfactory type adjusts the valve to any position be-

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tween closed and wide open, so that the water admitted to the boiler is always just sufficient to supply the quantity leaving the boiler as steam. This makes the change in the rate of feeding the boilers much more gradual, which is the condition most favorable to safety and good economy. The function of the regulator is not to replace the water tender but to relieve the water tender of the extremely troublesome detail of continually adjusting feed valves. This is no small task in a boiler plant having from 10 to 20 boilers, in various stages of generating steam, and when the water tender is relieved from this continuous performance of manipulating valves, he can devote his whole attention to the supervision of the water-level of the boilers. The water tender is always an experienced fireman, and he should combine the supervision of the fires with that of the water-levels. This he can do the more easily when the feed-water regulators control the supply of water to the boilers. It is perhaps unnecessary to add that each boiler should be equipped with the best water columns obtainable, and that these columns have gauge-glasses and three try-cocks, operated by rods or chains from the point most convenient for the water tender. Working around water columns, or replacing gauge-glasses when the boiler is under steam, is always dangerous, because of the liability of the glass to burst, causing injuries to the face and particularly the eye. For this reason only the highest class gauge-glasses should be used, and these protected by guards. We have, by the use of high-grade gauge-glasses, divided the former number of breakages by six, averaging for a whole year throughout a large number of plants. This, of course, reduces the liability to serious accident in the same proportion, and the proper use of guards still further reduces this. There is no telling how many cases of blindness of one or both eyes have been prevented by attention to a comparatively simple detail of this kind.

Safety Valves—Attention to the kind and capacity of safety valves is a very important matter. It was formerly the custom to put on boilers of a certain capacity a safety valve, or two valves, without anyone knowing anything as to how much steam the valves would discharge per minute. In order to protect the boiler properly, the safety valves should have sufficient capacity to discharge the full quantity of steam which the boiler will generate with the main steam outlet closed. Safety valves as now manufactured have a guaranteed discharge capacity under specified conditions, and in this way it is possible to be sure that there is enough valve area on every boiler to make the conditions safe. Also, the valves should be tried every day, in order to be sure that they work freely. This is a very simple matter, and does not take much time if proper provision is made for it.

How Much Fuel Does a Clean Boiler Save?

Chart Showing Amount of Fuel Saved After Cleaning Boiler. Temperature of Chimney Gases Before and After Cleaning Only Readings Necessary Beyond Fuel Value of Coal Used.

By W. F. SCHAPHORST

Copyright, 1918.

Here is an interesting and valuable chart for finding the fuel saved by keeping boilers clean. Simply zigzag across the chart three times with a straightedge or fine black thread, as indicated by the dotted lines drawn across, and the per cent of fuel saved is found in the last column at the right, column G.

For example, if the temperature of the chimney gases before cleaning was 580 degrees F., and after cleaning 480 degrees F., and if the heat value of the coal is 12,000 Btu per pound, what is the percentage of fuel saved?

Connect the 580 (Column A) with the 12,000 (Column C) and make a note of the figure intersected in Column B. In this case we find the figure in Column B to be 70 per cent. Now begin at the 12,000 (Column C) and run a line through the temperature difference (before cleaning and after) in Column D, which is easily figured mentally to be 100 degrees. Continue the line until it intersects Column E. Column E, you will note, is intersected at 3.8 per cent. Now from this point, (Column E) run through the figure in Column F, which is the sum of the figures obtained in Columns B and E. In this example the sum is (70 + 3.8 per cent) 73.8 per cent. The continuation of this last line through Column G gives the answer as 5.15 per cent.

The instructions on the chart itself tell just what to do as you go along. Each column is fully explained, excepting Columns B and E, which are to be "added together" for use in Column F. In zigzagging across, the second line from Column C to Column E begins where the first line ended, at the 12,000 Btu, the 13,000, or whatever it happens to be. In this example it is 12,000 Btu. In the same way, the third line, from Column E to Column G, begins where the second one ends.

The writer has experimented with this chart to find which is quicker, the chart itself or the formula on which the chart is based. In every instance I found the chart to be much the quicker. The only mathematical operation involved, adding two simple numbers, requires very little time or thought and can frequently be done mentally.

Why the Chart Was Developed.

Not long ago I developed and published a formula for computing the fuel saved by cleaning boilers. This formula met with considerable approval. One

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correspondent, however, asked if I could alter the formula and get rid of the "boiler efficiency factor" which was contained in the formula. Many operators of boilers haven't an inkling regarding their boiler's efficiency, and so as soon as one begins to talk efficiency to them they shrug their shoulders and give up the task as hopeless.

With this correspondent's suggestion in mind I sought out some good representative steaming tests where I knew the firemen and engineers did the best they could and derived this formula:

$$\frac{100\ (T - t)}{0.22H - 0.37T - t} = \text{per cent of fuel saved assuming 18 pounds of air per pound of fuel.}$$

Where T = the temperature of the chimney gas before cleaning, degrees F.;

t = temperature of chimney gas after cleaning, degrees F.;

H = heat value of fuel in Btu per pound.

This is the formula upon which the chart is based. It contains the three most important factors, all of which are usually known or determined without great effort. T and t can be found by means of a pyrometer or a thermometer properly placed in the gases. If a thermometer is used, don't place it close to any comparatively cool body, or the bulb will radiate heat so rapidly as to affect the reading considerably. The heat value of the coal H can be ascertained with fair accuracy from Bureau of Mines publications, which list the heat values of coals mined all over the United States.

Naturally, the chart is subject to criticism. It is not claimed to be "perfect." No boiler efficiency formula can be expected to be perfect, containing only three factors, as this one does.

It is simple, however, and that is a thing that is always wanted. It shows clearly that low initial temperature in exit gases is most desirable. It shows that the cleaning operation should reduce the temperature as much as possible. The lower the final temperature the better. It also shows that it is desirable to use high quality coal—coal of high heat value. The lower the initial temperature and the higher the heat value of the coal, the more difficult it is to save coal, because under such conditions the efficiency of the boiler is already high.

The range of this chart is great enough to include most boilers. The efficiencies range from 50 to 100 per cent. The maximum temperature decrease shown is 220 degrees F., which is sometimes exceeded but seldom is an average decrease. Column G shows that the chart will compute savings all the way from 2 to 15 per cent. Should your problem be so unusual as to fall outside of this chart, which is improbable, recourse may be had to the formula which is given above.

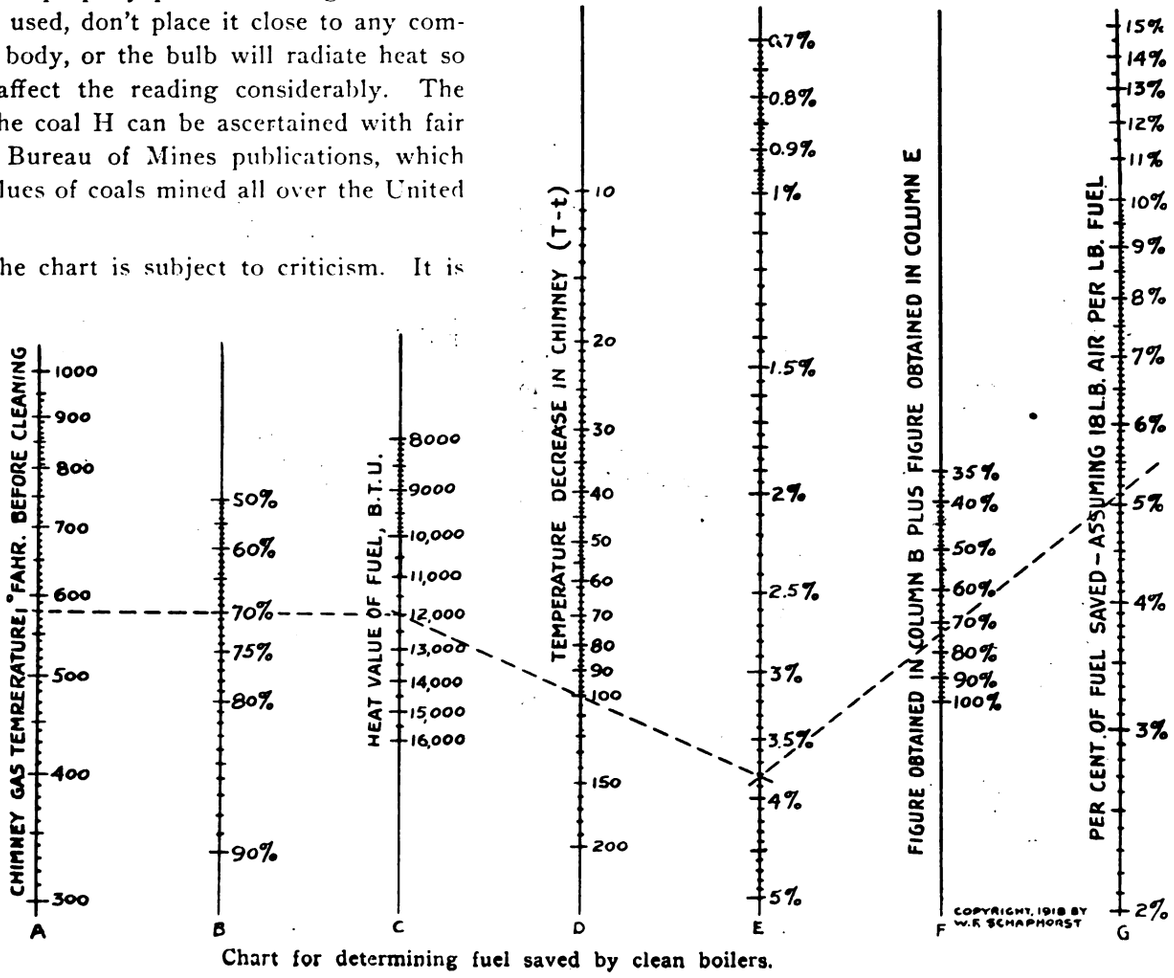

Chart for determining fuel saved by clean boilers.

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FOREIGN RELATIONS

MANGANESE INDUSTRY OF TRANSCAUCASIA.

Vice Consul H. A. Doolittle, Tiflis, 1919.

Manganese occurs in Transcaucasia practically only in the Tchiatouri region, not far from the port of Batum, with which it is connected by rail. The ore is found where it outcrops and in beds, and it is mined like coal, through tunnels or adits. The richest ore, containing up to 90 per cent pure manganese dioxide, occurs in the village of Perevis, and the most productive mines are in the hamlet of Mgvimevi.

Figures showing the export of manganese to different countries for 1913 and 1914, the last two years during which exportation was possible, are given (in poods of 36 pounds) in the following table:

Countries	Poods. 1913	Poods. 1914
Austria-Hungary	1,553,564	2,010,619
Belgium	11,163,109	9,577,121
France	3,367,972	1,484,999
Germany	3,186,089	3,755,114
Great Britain	15,091,103	6,696,517
Italy	451,192	563,210
Netherlands	21,987,330	16,482,099
Roumania	.....	4,500
South Russia	617,500	936,400
United States	8,409,407	2,142,323
Total	65,827,266	43,652,902

After war was declared communication with the outside was cut off and practically no export was made, the only consumer being Russia.

War Seriously Affects Industry.

The year 1914 began with good prospects for the manganese producers of Tchiatouri and thus continued for the whole first half of the year. There was a considerable call abroad for the product of the mines, and an intensified exploitation to satisfy this demand was made while prices were fairly favorable.

The declaration of war seriously affected the production of manganese, cutting down the amount mined in 1914 to 18,742,000 poods less than the production in 1913. This was due to the shutting down of a considerable number of mines and to the limited exploitation undertaken in the latter half of the year. During the year the number of mines and drifts under exploitation was 192 and 226, respectively, as against 303 and 437 in 1913. In other words, the number of mines was reduced by 36 per cent and the number of driftways by 48 per cent.

At the same time the number of firms engaged in this industry fell from 260 in 1913 to 175 in 1914, a reduction of 32.69 per cent. This is 17.45 per cent below the average for the preceding 10-year period. The totals of production for later years also show a considerable decrease; thus in 1915 there was produced only 15,737,000 poods, and in 1916, 14,677,000 poods.

The mines with drifts under exploitation for the three years are as follows: In 1915, 95 mines and 153 drifts; in 1916, 106 mines and 144 drifts; and in 1917, 84 mines and 96 drifts.

Operation of Concentrating Plants.

In the Tchiatouri region, up to 1914 there were 27 concentrating plants. In the following table, taken from a publication of the Council of Manganese Producers, is shown the number of plants in operation for the years 1914, 1915, 1916, and 1917, together with other particulars:

Year	Plants	Ore received at plants	Amount of washed ore	Loss in washing	Laborers For washing	Laborers For handling
	No.	Poods.	Poods.	Per cent	No.	No.
1914	18	23,241,000	15,067,000	35.17	478	200
1915	18	12,530,000	7,817,000	37.61	170	15
1916	22	17,228,500	9,568,800	44.51	417	38
1917	21	11,967,000	6,668,000	44.27	222	30

In 1914 only 18 out of 27 plants were running, making the production smaller than that of 1913 by 7,000,000 poods; however, taking into consideration that the plants were operated practically only during the first six months of 1914, it will be remarked that in that year the production of every plant increased, and if war had not occurred an output nearly twice as large as the one indicated would have been obtained by the end of the year. The next year, 1915, the same number of active plants produced only 7,817,000 poods of washed ore. In other words, the production decreased by 7,250,000 poods, or 47 per cent. In 1916 the number of active plants and the amount of ore produced in connection with the demands of the Russian metallurgical factories making war materials increased, but in 1917 there was a still more noticeable fall in the amount of washed ore. In comparison with the production for 1914, this 1917 output shows a decrease of 8,399,000 poods, or 55.7 per cent.

Ore Imports—Georgian Producers Amalgamate.

Imports of ore into Russia amounted to 1,345,107 poods in 1915, 10,859,452 poods in 1916, and 2,881,260 poods in 1917. This was a considerable increase in the amount of manganese consumed by Russian industries over the pre-war period, which previous to 1915 had never exceeded 2,000,000 poods in any one year. Another point to be noticed is the enormous decrease for the year 1917, showing how greatly the revolution, with its attendant labor troubles, affected the industries using manganese.

Notwithstanding the decrease in production during the war, the lack of opportunity to dispose of the ore left the manganese producers of this region with enormous stocks on hand at the end of the year 1917. Practically no mining was undertaken in 1918, except that during the German occupation a certain amount of cleaned ore was prepared to be shipped to Germany. No figures were kept either of production or of the amounts sent to the Central empires.

At the present time, at the port of Poti and at Tchiatouri, there are approximately 58,000,000 poods of cleaned ore, above ground, ready for shipment. This ore varies in quality from 50 to 60 per cent, ordinary, up to 88 to 90 per cent pure dioxide. Most of the Georgian producers have combined to form the Manganese Producers' Stock Company (Actionnerny Obshtchestvo Margantseiprompshlennikov), a semi-governmental institution which is designed to control the industry, in spite of the fact that they own only 15,000,000 poods out of the 58,000,000 above ground. Three-fourths of the remainder is controlled by the two great exporting firms of Tchilingiurian Bros. and M. Manuelides of Batum. These two firms are not actual producers, but are buyers and exporters.

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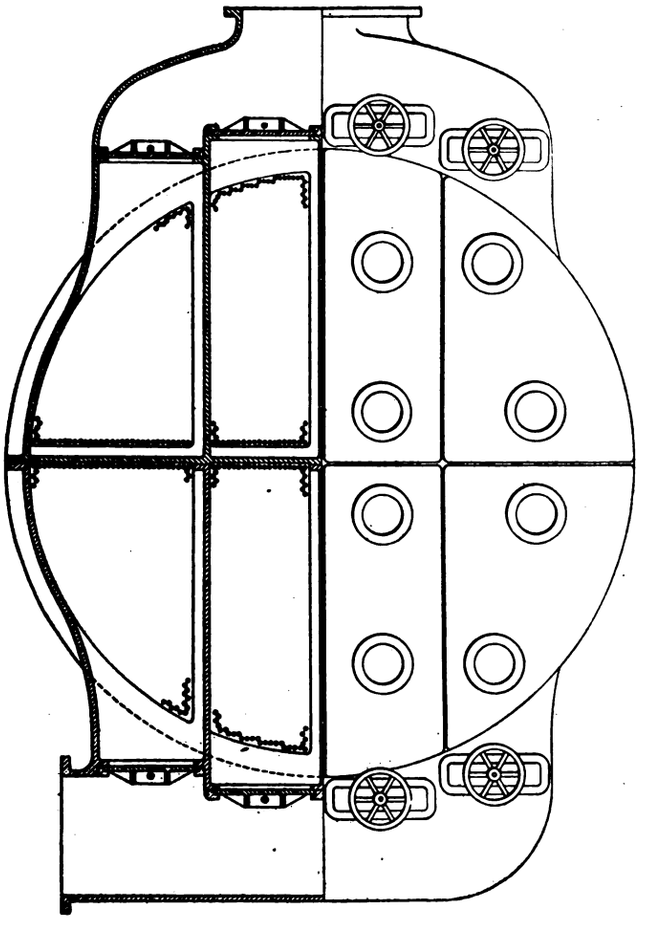
PRODUCTION TOPICS

CONDENSER CLEANED WHILE IN SERVICE.

A new and valuable development in steam surface condensers is announced by the Wheeler Condenser & Engineering Co., Carteret, N. J. It is a patented "compartment condenser" that can be cleaned while in service without shutting down the turbine. Any tube or tubes may be temporarily plugged and other repairs made without taking the condenser out of service.

This is a timely development in view of the persistent claims made by well known fuel authorities that the price of fuel is not likely to go down for some time if at all. This condenser



will enable the chief engineer to constantly maintain clean condensers, hence a constantly high vacuum. All engineers of experience know that in addition to increasing output a high vacuum means low fuel consumption and a considerable saving in money year in and year out.

Also upon installation of this condenser there need be no interference with the operation of the turbine. At the present time, in many important power stations, even where water conditions are regarded as good, it is necessary to occassionally shut down the turbine for a period sufficiently long to give the condenser a thorough cleaning. In such cases, and in fact in all cases where continuous and highly efficient operation are desirable, this new type will fill a long felt want.

To clean the average condenser is not a difficult task, but it is time-consuming, and for that reason the chief engineer is naturally tempted to put cleaning off until "tomorrow," or "next week," or "next month." During his wait for the opportune time the vacuum gradually drops, and with the drop coal wastage increases. Sometimes the loss of vacuum amounts to several inches of mercury. Hence the compartment condenser, which can be kept constantly clean regardless of load conditions, will in the long run prove to be a paying investment from the standpoints of both uninterrupted service and coal saving.

The illustration shows clearly how the compartments are arranged. The condenser shown is divided into four compartments, each compartment being equipped with a set of valves to control the circulating water. To clean the condenser while the turbine is delivering full power, the operator simply shuts off the water from one compartment, removes the cover, cleans the tubes, replaces the cover, turns on the water again, and then passes on to the next compartment repeating the operation until the four compartments or the entire condenser is clean. Thus, while one compartment is being cleaned, the other compartments are in full operation, temporarily taking over the entire turbine load.

An advantage that will not be overlooked by engineers in localities where water is bad is that no matter how severe the water conditions may be, the compartment condenser will take care of the cleaning problem. Shut downs for frequent cleaning will become a thing of the past. This condenser can be cleaned as many times per week or month as desired.

OVERFIRED CAR TYPE ANNEALING FURNACE.

(Continued from page 450.)

production started, but it was noted that some differences existed in the physical qualities of the steel at various points on the circumference, thus surface, which was upward in the furnace during treatment having different characteristics than those surfaces of the circumference, that were downwards and laid near the top of the car; as the results obtained were not satisfactory a careful investigation of conditions was made and it was found that while the upper half of the circumference of the steel ring, which could "See," the radiant surfaces at the top of the furnace was heated to the proper temperature of 1,600 degrees, it was impossible to bring the lower half of the ring to temperatures greater than 1,550 degrees to 1,570 degrees. On the normalizing heat, the temperature differential was even greater, approximating 100 degrees.

It was very evident that to secure satisfactory operation, and results from this equipment, that an auxiliary supply of heat would have to reach the work on the surfaces of the under-circumference. After considerable experimenting at the steel company's plant a system was devised by which a number of small burners and combustion chambers were placed in the wall, a short distance above the level of the car. The illustration gives sectional views of this furnace, showing the auxiliary burners. A system of flues, originating just under the perforated arch, and on the same section line as the burners, were introduced—this arrangement also being novel in the overfired furnace. Wonderful results were secured after the auxiliary burners and flues were introduced. A most careful test shows that the difference in temperature on either the annealing or novelizing heat, between the top and bottom of the piece were no greater than the area of the heat measuring instruments indicated that they were within 10 degrees. The original furnace was installed by Tate, Jones & Co., furnace engineers, Pittsburgh, Pa., and the experimental work leading thereto and the changes and addition of the lower burners and upper flues were made by that concern. The introduction of the double burner flames in the overfired type of furnace were so entirely novel that a basic patent was secured covering the overfired furnace with auxiliary burners at or near the hearth.

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INDUSTRIAL RELATIONS

INDUSTRIAL TRAINING HELPS REDUCE HIGH COST OF LIVING AND SOLVE INDUSTRIAL UNREST.

Col. Arthur Woods, assistant to the Secretary of War, is urging 20,000 factory owners and industrial corporations throughout the country to undertake industrial training for their workers at the same time that they pay them a sufficient living wage during the period of their apprenticeship.

With the cost of living soaring daily higher, the question of efficiency in production and manufacture has come to the front as the issue of most fundamental importance in the solution of the living problem. It is becoming clear that some remedy must be found for a situation in which thousands of American workers, earnest, respectable men who are doing their best every working day of the week, are nevertheless attaining an output of not over 35 per cent of their best human capacity.

American factories are today using 6,000,000 or more workers to do what 4,500,000 men could do as well if they were fairly trained. This means that American manufacturers are paying the wages of 1,500,000 workers who are really adding nothing to the total output of the industrial system. In the manufacturing section of New England, and a few portions of the United States are more important in the production of our daily necessities, factory experts have stated that the factories are not more than 60 per cent efficient in output, merely for want of more skilled and intelligent manpower. This does not compare very well with a pre-war Germany in which individual industrial training was so successfully operated that 65 per cent of the managerial and technical force consisted of men who had started work as unskilled or semi-skilled labor.

In aggravation of the high cost of living, the entire question has been brought to a head just now by the large numbers of soldiers returning to civilian life from the military service. Many of these men went to war unskilled workers, but because of their experience have come back with greater ambitions and larger vision. They have the psychological start for better things. They have the desire to improve their condition and their earning power. But they have neither the skill, nor the means for developing the skill, without which their ambitions cannot possibly be realized. They must have industrial training immediately and on a sufficiently large scale to offer an opportunity for advancement to every man who wants one and deserves it. These men must earn a living wage while they are learning, and must be taught intensively enough so that in a short time they will be able to realize their ambitions and to increase their earning powers.

That greater production means lower prices is axiomatic. That this result can be accomplished with those very men who are at present classed as unskilled laborers is abundantly proved by the experience of a number of factory owners. The superintendent of one of the biggest metal working establishments in the country, states that mechanics who had been with them for two years were given one week of training, as a result of which they doubled their individual production. In another plant a worker returning from the training department by 11 o'clock did what has been estimated formerly to be a day's work. In a shoe factory in Brooklyn, 60 soldiers were recently employed who had had no previous training in shoe production, and who were taken on with the avowed intention of being put through the training course in order to be taught their trade. The men started at $15 per week and after a training varying from three to six weeks some of these men are earning as high as $70 a week.

Bearing in mind these random illustrations of the possibilities of industrial training, what is the country doing today to accomplish the same result on a larger basis? The answer can be given briefly without noticeable inaccuracy. It is doing just exactly nothing at all. The United States spends $700,000,000 annually on general education. It spends $5,000 of public money on anyone who has sufficient means to live without wage earning in the years between 16 and 21. But it seldom spends a single dollar on making a mechanic. Where millions are spent for a few thousand professionals, nothing is spent for the millions who produce our necessaries. So long as this condition persists, no remedy for the high cost of living can be successful because it is only by going to this fundamental feature of the problem that anything can be accomplished.

At the outbreak of the war, the need for increased productivity in the industrial system was clearly appreciated by the country's leaders. The United States Training Service under the Department of Labor was organized to promote training classes in industrial plants and offered its free services to manufacturers in starting such classes. By these means during the war, large numbers of unskilled workers were turned into skilled workers in a short time, and the entire available fund of skilled labor was markedly increased thereby. Not only did these training classes produce new men, but they also increased the level of ability of many of the old ones and increased the efficiency of the entire plant. Congress having failed to provide the necessary appropriation for continuing the work, this national effort has lapsed into inactivity, with the result that today 20,000 industrial corporations in the United States that could advantageously adopt such a plan of industrial training, are doing nothing to raise the level of their men, increase the productivity of their plants or to increase the general level of production throughout the United States.

What industrial training means in terms of advancement for the workers of the United States can scarcely be overestimated. A great majority of our 10,000,000 factory workers confront a changeless task that they do not really comprehend and will never get a chance to master or escape. It has recently been said that "labor unrest at this time is an effort to secure a recognition of personality." This is absolutely fundamental to the solution of our industrial and labor problems. High wages alone will get us nowhere, because the monotony of a routine task and the lack of opportunity for advancement will not be replaced by a mere increase in the weekly payroll.

Nor will this be a difficult matter once the facts are clearly presented to America's industrial leaders, because not only is future productivity increased but the men more than pay for themselves at the same time that they are learning. More and more factories are beginning to discover that raising the level of skill of their workers is a paying investment which makes for contentment among their men, which produces leaders to take charge of the work requiring skill and intelligence, and which actually increases the profits and dividends by raising the general level of production to a high plane, by means of increased efficiency instead of expenditure. Labor, on the other hand, is responding eagerly to this idea because it means increased earning power to the individual worker, independence and better education. It makes for pride in his work and contentment with his prospects for every laborer who is thus given an opportunity to better his condition and improve his status as his skill increases. The public, finally, sees in this a fundamental approach toward solving the high cost of living, and completes the tripartite national approval on which the success of the plan depends.

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NEWS OF THE PLANTS

The Youngstown Pressed Steel Company, Youngstown, O., is making rapid progress in the construction of its new plant near Warren, O. The company has a large tract of property in this district covering about 40 acres of land. The main building of the new plant will be about 530 x 560 feet, of brick, concrete and steel construction. The equipment will be electrically-driven, and will include machinery for the manufacture of pressed steel parts for automobile, truck, tractor, and other use, as well as for fireproofing materials, such as metal lath, expanded metal, and other special steel products. It is planned to have the new works ready for operation early in November. The company is affiliated with the Sharon Steel Hoop Company, and the plants now used at East Youngstown, O., and Sharon, Pa., will be used by the latter organization on completion of the new works.

The Interstate Iron & Steel Co., Chicago, Ill., has arranged for a stock issue of $1,400,000 for proposed extensions and betterments. The proceeds will be used in part for the construction of an addition to its open hearth furnace and continuous rolling mill at the East Chicago works, including the installation of new machinery and equipment to facilitaate the handling of raw materials at this plant. The works specialize in the production of merchant bar iron and steel. A rolling mill is operated by the company at Marion, O. Silas Llewellyn is president.

The Robesonia Iron Company, Robesonia, Pa., has resumed activities at its local blast furnace, and will maintain a production of about 1,400 tons of iron per week for some time to come.

The Hammond Steel Company, Syracuse, N. Y., is planning for extensions and improvements in its plant to cost about $250,000. The work will include a new rolling mill, about 80 x 260 feet, with wing, 40 x 60 feet; a number of new furnaces, and electric power plant. The company recently increased its capital from $1,000,000 to $1,700,000.

The Wyckoff Drawn Steel Company, First National Bank Building, Pittsburgh, Pa., recently incorporated with a capital of $500,000, has inaugurated construction work on a new rolling mill at Economy, Pa., about 20 miles from Pittsburgh. The plant will be equipped for the production of rounds, flats, squares, hexagons, both in carbon and alloy steel, as well as drawn and turned shafting. The machinery will be electrically-driven, and considerable special equipment for production will be installed. The company has purchased a tract of land comprising about 12 acres at the new location, and the initial works will occupy about two acres of ground. It is planned to have the new plant in operation early in the new year. A. W. Wyckoff is president; G. R. Nutty, vice president; and P. M. Nutty, secretary and treasurer.

The Slick-Knox Steel Company, Wheatland, Pa., is planning for the immediate erection of a new one-story machine shop, about 70 x 250 feet; an electric power plant will also be constructed for works operation, as well as a new two-story office building.

The Phoenix Iron Works, Meadville, Pa., has commenced the construction of a new two-story brick and steel machine shop, about 64 x 240 feet, for increased capacity in this department of works operation.

The Carnegie Steel Company, Pittsburgh, Pa., has completed the rebuilding of its blast furnace No. 3, at the Farrell, Pa., plant, and the unit has now been blown in for service for the production of pig iron. The capacity has been increased from 350 to 500 tons.

The Nagle Steel Company, Seyfert, near Reading, Pa., is making a number of extensions and additions at its plant for increased facilities. New equipment has been installed for the rolling of thin steel plates.

The Midvale Steel & Ordnance Co., Widener Building, Philadelphia, Pa., is planning for extensive improvements and additions at the Franklin plant of the Cambria Steel Company, Johnstown, Pa. The work will include the installation of new machinery and equipment, the reconstruction of present boiler plant, improvements at the plate mill, as well as the erection of a new hospital for employes at the works. At its Nicetown plant, the company is planning for the erection of a new electric furnace, and will also make improvements and extensions in the bar mills for the production of tool steel and other bar products. At the Coatesville works the company plans for the erection of a new special heat-treating plant, as well as other improvements and additions. The entire work is estimated to cost about $8,000,000.

The Pratt & Letchworth Co., Buffalo, N. Y., is now operating its new malleable iron foundry, recently completed. The plant consists of three bays, two of which are 70 x 540 feet, and one 70 x 215 feet. An extension, about 60 x 220 feet, has also been constructed to house the annealing ovens. The new structure is of brick and steel, and replete in all departments.

The Pittsburgh Forge & Iron Co., Pittsburgh, Pa., has resumed operations at a portion of its Woods Run plant after a shut-down for about two weeks to allow for improvements and repairs. The departments now in operation include the bar, guide and puddling mills. It is planned to inaugurate operations in the forge department at an early date.

In connection with its proposed plans for general expansion, the Clinton-Wright Wire Company, Worcester, Mass., recently formed by the merger of the Wright Wire Company, Worcester, and the Clinton Wire Cloth Company, Clinton, Mass., plans are now under way for the erection of a large addition to the plant at Palmer, Mass., for wire-working operation, increasing the present capacity by about 10,000 tons per year. Considerable new wire drawing machinery will be installed. The company has preliminary plans under way for the construction of new steel mills, and is considering Buffalo, N. Y., as a site for the proposed expansion. George M. Wright is chairman of the board of directors.

The Canonsburg Steel & Iron Co., Canonsburg, Pa., is planning for extensions and improvements at its plant to increase the present capacity. It is proposed to add two hot mills at the works, and it is understood that contracts for the equipment will be placed at early date.

The Wharton Steel Company, Wharton, N. J., has resumed operations at its local plant following a shut-down for about two months past, due to a strike of employes. It is understood that the works will run at capacity until further notice.

Efforts extending over a year for establishment in Louisville of a malleable iron foundry—the basis of a number of other industries sought by the Louisville Industrial Foundation, has resulted in a transaction whereby a $500,000 plant will be erected immediately by the Illinois Malleable Iron Company, Chicago, capitalized at $2,500,000.

Representatives of the Chicago concern, at a conference at the Industrial Foundation, concluded a deal, through J. Lithgow Smith, of the Fidelity & Columbia Trust Co., and Caldwell Norton, for purchase of 40 acres belonging to the Merhoeff estate at the intersection of Ash Bottom road and the Southern Railway tracks, across from the army remount station.

Operations will be started by December 1, according to announcement, and 500 operatives will be employed. The concern will have an output estimated at between 6,000 and 10,000 tons of malleable iron a year. It is announced that erection of the plant will be started immediately.

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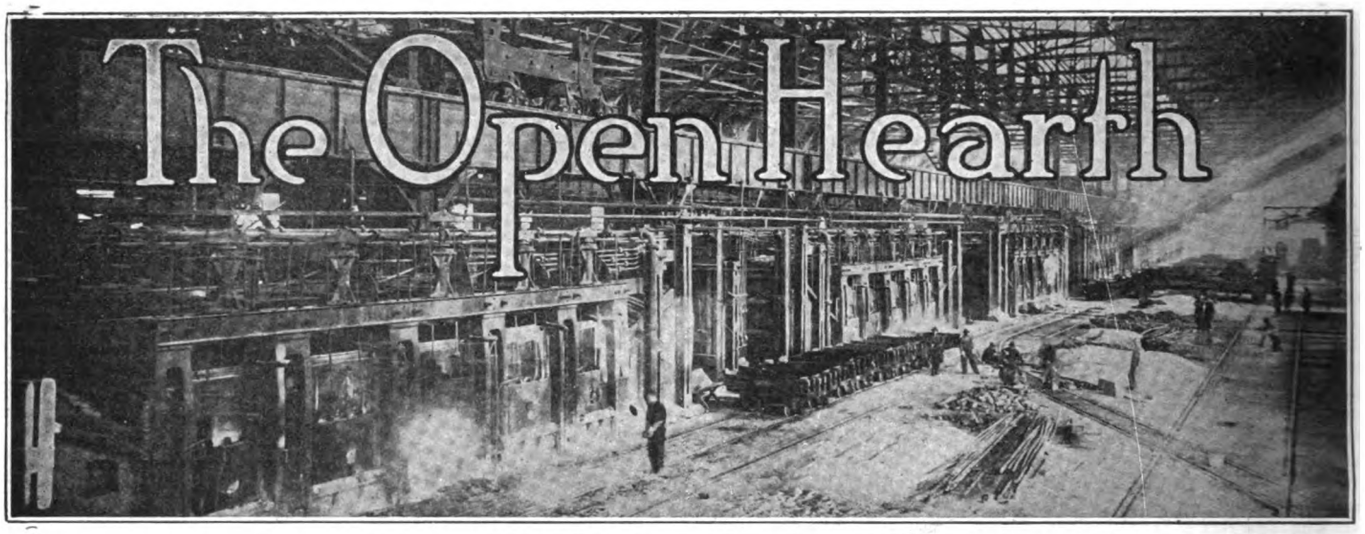

B. L. Cogshall has been appointed assistant to president of the Pittsburgh Steel Company. Mr. Cogshall was previously manager of production of the United Alloys Steel Corporation, prior to which he was connected with the Illinois Steel Company.

V V

Charles A. Swan is now general superintendent of the Crucible Steel Forge Company, Cleveland.

V V

George Stitch, formerly with the Huntington Steel Foundry Company, Huntington, Ind., is now connected with the Union Sanitary Manufacturing Company, Noblesville, Ind.

V V

George W. Pope, after having been connected with the Hog Island ship yards for two years has now returned to the Minneapolis Steel and Machinery Company, Minneapolis as structural sales manager.

V V

Q. S. Snyder is now vice president and treasurer of the Pittsburgh Rolls Corporation, succeeding H. R. Warfield, resigned.

V V

N. B. Folsom who for some time has been acting in the capacity of treasurer of the Brier Hill Steel Company, Youngstown, O., since the retirement of John Stambaugh, was recently elected treasurer of the company and manager of the board of directors.

V V

W. C. Greer, formerly superintendent of the Seward Foundry, previous to which he was foreman for the Verona Steel Castings Company, is now connected with the McKenna Brass & Manufacturing Co.

V V

M. B. Summers is now secretary of the Stalmaker Steel Company, succeeding F. S. Easterly, resigned.

V V

William Lewis, has been appointed to take charge of operations for the Falcon Steel Company, now building at Niles, O. Mr. Lewis was formerly superintendent of the sheet plant of the Western Reserve Steel Company.

V V

R. C. Gosrow, is now in Seattle engaged in electrometallurgical engineering work and metallurgical and industrial sales engineering. Mr. Gosrow was formerly electrometallurgist for the North American Company, New York, and was sales manager for the Pittsburgh Furnace Company and the General Steel Company, Milwaukee.

V V

M. J. Gregory has been appointed foundry superintendent with the General Motors Corporation. He will operate the foundry of the Samson Tractor Division, Janesville, Wis., upon completion.

J. Leonard Replogle, president of the American Vanadium Company is now also one of the directors of the American Ship and Commerce Corporation, holding company for Cramps-Kerr Steamship Company.

V V

Richard Hunt Hallstead has been elected president and treasurer of the Sheffield Steel & Iron Co., Chicago, at its recent organization. H. C. A. Mitchell was elected vice president and general manager and John W. Taylor, vice president and sales manager.

V V

L. H. Meyer is in charge of the Pittsburgh office, Oliver Building, of the John W. Cowper Company, Inc., Buffalo, engineer and contractor.

V V

Capt. Giles S. Pease has just returned to this country after being abroad a year and a half in the service of the American Red Cross. He was formerly plant engineer of the Spencer Wire Company, Worcester, Mass.

V V

Ralph T. Fuller has been elected vice president of the Producers Fuel Company, First National Bank Building, Pittsburgh. Mr. Fuller has for the past 10 years been associated with the sales department of the M. A. Hanna & Co., Cleveland.

V V

M. W. McClane is now president of the Aetna Foundry & Machine Co., Warren, O. M. W. McClane, W. M. McKee, G. P. Gillmer and V. E. Rehr were elected directors of the company, Mr. Rehr being made vice president; G. P. Gillmer, treasurer, and M. C. Boyd, secretary.

V V

William H. Woodin, president of the American Car & Foundry Co., has been elected a director of the American Locomotive Company. W. Spencer Robertson, of the American Locomotive Company, has also been elected a director.

V V

Robert L. Kift, formerly vice president and general manager of the Bethlehem Construction Company, has resigned from this position and purchased the Lehigh Structural Steel Company, Allentown, Pa. Thomas R. Mullen is general manager of sales.

V V

B. F. Bart is now sales manager of the Standard Seamless Tube Company, Pittsburgh, comprising the territory of Philadelphia, New York and New England.

V V

F. J. McGrail has charge of the foundries operated by the Honolulu Iron Works Company, Honolulu, Hawaii. Mr. McGrail was formerly superintendent of the Struthers-Wells Company, Warren, Pa., previous to which he was connected with the Worthington Pump Company, Harrison, N. J.

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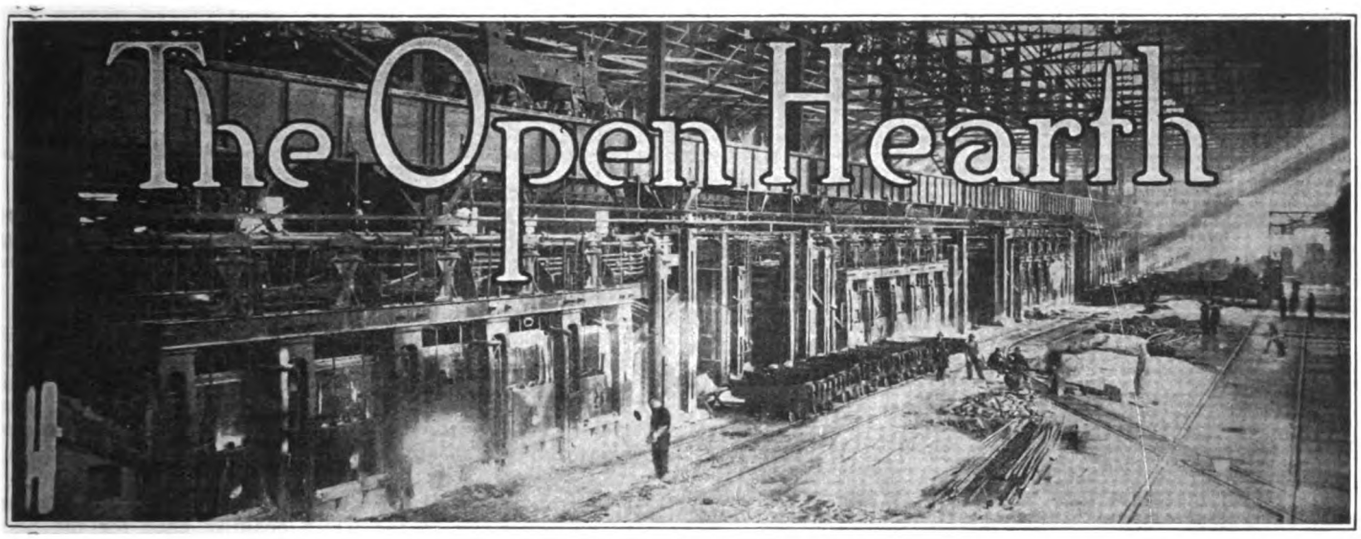

R. E. Blood has opened offices in the Hudson Terminal Building, Room 523, 30 Church street, New York, and is Eastern representative for the Lockhart Iron & Steel Company, Pittsburgh, and also the Pittsburgh Rivet Company. Mr. Blood, previous to this connection has been associated with the American Locomotive Company.

V V

George E. Jurey has resigned as chief clerk in the open hearth department of the Republic Iron & Steel Co., and is now auditor of works of the Jones & Laughlin Steel Co., Pittsburgh.

V V

J. L. Dixon is now associated with the T. W. Price Engineering Company, Woolworth Building, New York, as metallurgist and electric furnace engineer. Mr. Dixon was formerly associated with the John A. Crowley Company.

V V

Edward Shearson has resigned as a director of the American Steel Foundries.

V V

George W. Short has resigned as vice president and general superintendent of the Sharon Steel Hoop Company, Sharon, Pa., with which company he has been connected for 12 years. He is director of the recently formed Slick-Knox Steel Company.

V V

Charles Yon and Lawrence Snapp are respectively president and secretary and treasurer of the United Fuel & Iron Co., dealers in coal, coke and scrap iron, House Building, Pittsburgh.

V V

Louis Resnick has been appointed director of publicity for the National Safety Council, Chicago. He was general manager of the Associated Trade Press, of which he was the founder. Prior to that he was connected with the Associated Press for about four years, first as editor of the night bureau at St. Louis, and later as editor of the west wires in the central division office at Chicago.

V V

William H. Moreman is now general superintendent of the Milwaukee Corrugating Company, Milwaukee. He was formerly connected with the Truscon Steel Company as superintendent of the sash department.

V V

S. I. Sterret, formerly purchasing agent of the Republic Iron and Steel Company, Youngstown, O., is now in the employ of the Kelly Island Lime & Transportation Co., Cleveland.

Andrew K. Barr is now foundry superintendent of the Gibby Foundry Company, Boston, Mass., at the Wakefield, Mass., branch.

V V

S. H. Hedges, formerly assistant purchasing agent of the Republic Iron & Steel Co., is now purchasing agent, succeeding S. I. Sterret.

V V

Malcolm E. Gregg is now associated with the sales department of the Lackawanna Steel Company, Buffalo. He was formerly district sales manager of the Republic Iron & Steel Co., at Buffalo.

V V

Allan Johnston Goodhue has retired as Western sales manager of the United States Cast Iron Pipe & Foundry Co., terminating a career of 34 years duration, in which he was connected with the cast iron pipe business.

V V

J. H. Schoenly is now vice president and general manager of the Bethlehem Construction Company, Bethlehem, Pa.

V V

W. L. Tedford has been appointed European representative of the Commonwealth Steel Company, St. Louis. He will be located at Paris, France.

V V

George A. Paul and C. L. Jahn, recently with the American Expeditionary Forces, have joined the staff of the Pennsylvania Steel Export Company, Widener Building, Philadelphia.

V V

A. M. Conneed, New York sales manager of the structural and plate departments of the Bethlehem Steel Company, is now vice president and general manager of the Hedden Iron Construction Company, New York.

V V

A. W. Thompson resigned as president of the Inland Steel Company, Chicago. P. D. Block, vice president, was recently elected president at a quarterly meeting of the directors. G. H. Jones, vice president, was elected first vice president. E. M. Adams, secretary; E. J. Block, assistant to vice president, general purchasing agent and assistant secretary and assistant treasurer; H. C. Jones, assistant to vice president, were elected vice presidents. D. P. Thompson, assistant to vice president becomes assistant to president. G. W. Lees, superintendent of the Indiana Harbor plant has been appointed works manager.

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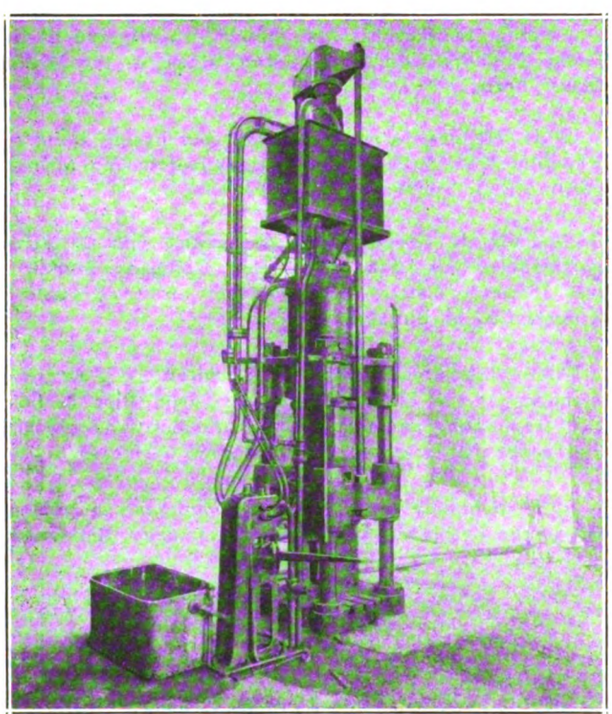
WITH THE EQUIPMENT MANUFACTURERS

FORGING PRESS FROM PIERCING PRESS.

The question as to how to utilize the hundreds of standard shell piercing presses in use at the close of the war has been solved by the Southwark Foundry & Machine Co., of Philadelphia. They have designed a single lever high speed valve control which converts the piercing presses into high speed forging presses. A low pressure filling tank is also provided thus to make the high speed presses economical in operation.

It is stated by the manufacturer that a 350 ton press, thus equipped, is in operation in the company's shop on general forging work, and it makes from 25 to 30 full capacity strokes per minute and from 50 to 60 light working strokes per minute. This speed is accomplished by using only the pullback cylinder, that is, exhausting the water from the pullback quickly, using the weight of the moving parts of the press for swedging work.



Standard piercing or drawing press converted into quick-acting forging press for general forging work. It is equipped with high-speed valve control.

The low pressure filling tank is located on top of the main cylinder, to which is attached a special casting forming the bottom of the filling tank. This tank bottom is provided with a large low pressure filling check valve. In order to reduce the overall height of the press, the pullback is located inside of the filling tank. The main cylinder, the pullback cylinder and low pressure filling check valve are all operated by the one lever. By moving the operating valve lever from its neutral position slightly downward, the pressure water from the pullback cylinder is exhausted, the low pressure filling valve operating the main cylinder is lifted so that when the moving platen descends, low pressure water from the tank fills the main cylinder until the die comes in contact with the forging. Immediately after this, the valve lever is moved still further, allowing the high pressure water to enter the main cylinder, doing the actual forge work with the full capacity of the press.

By raising the valve lever, the filling check valve is opened, pressure is applied to the pullback cylinder, which will return the moving platen of the press, exhausting the water from the main cylinder back into the filling tank, while the additional volume of water which has been used from the high pressure system, will pass through the overflow pipe from the tank back into the suction tank of the pump.

It is pointed out that this type of press will require a comparatively small size accumulator while the pump capacity will be equal to the water quantity used for the short high pressure stroke for a certain number of strokes per minute.

RYERSON QUINTUPLE PUNCH AND SHEAR.

The quintuple combination punching and shearing machine is a recent product of Joseph T. Ryerson & Son, Sixteenth and Rockwell streets, Chicago, Ill. This machine is built with a steel frame which affords ample strength for the heavy service required of it, without making the weight or bulk unnecessarily great. The combination of five units in a single machine is the means of saving a lot of floor space; and where several operations are to be performed on the same piece of work, time is also saved which would otherwise be required to transport heavy pieces from one machine to another. No changing of attachments or tools is necessary to enable this machine to perform such operations as shearing plates or round and square bars, notching, section cutting and punching. Another advantage claimed for this machine is that it makes clean, accurate cuts without having any tendency to distort the shape of the work.

At the operating side of the machine there are no overhanging members; all parts of the driving mechanism such as gears, clutches, and flywheels being located at the opposite side. This constitutes an important safety feature. The different units of the machine are also located far enough from each other so that one or more operators will not interfere, if it is desired to use several parts of the machine simultaneously. The section cutter is given ample space to allow the operator to cut material right or lefthand as desired. All foot lever connections for operating the clutches are arranged so that they do not interfere with long plates when passing through the full length of the machine frame for slitting operations. Three-jaw automatic clutches are used, which are independent of each other. The clutch on the punch end is provided with a loose disk to permit adjustment of stroke at any desired position. The clutch for the slitting shear, bar cutter, and coping and notching mechanism can be operated by either a hand-lever or foot-treadle. The clutches for the punch and the section cutter are controlled only by means of treadles.

All gears and pinions of the machine are made of cast steel with teeth cut from the solid metal, with the exception of the motor gear on machines operated by direct-connected motor drive. The clutch gears and eccentric shafts run in bronze bushings provided with means for ample lubrication. Heavily constructed outboard bearing brackets take up all strain. When the machine is to be equipped with a direct connected driving motor, the motor bracket and a gear and rawhide pinion are furnished for mounting the motor at the top of the machine. Where belt drive is to be employed, a tight and loose pulley and a belt shifter are furnished with the machine.

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Some Pointers on By-Product Coke Oven Operations

ORIENT COAL COKE OVEN TESTS.

The United States Bureau of Standards has recently made some experimental-retort tests of Orient coal in which they investigated the influence of the temperature of coking upon the quality of the coke produced and upon the quantity and quality of gas made from the coal. The results of these tests will appear in Technologic Paper 134 of the Bureau of Standards. The tests were made by R. S. McBride and I. V. Brumbaugh.

The series of five experimental-retort tests made at various temperatures was made with an apparatus made available to the bureau through the courtesy of the Bethlehem Steel Company, Sparrows Point, Md., at which plant the equipment is regularly in use for testing coals to be used in their by-product coke ovens.

The coal used for four of these tests were the same samples as those used by the bureau in testing the coke plant of the Minnesota by-product coke oven with Orient coal. This coal came from the Orient mine of the Chicago, Wilmington & Franklin Coal Co., located at Orient, Franklin county, Illinois. Dut to a rather limited supply of samples not a large number of tests were made and the conclusions to be drawn from the tests are therefore to be accepted with reservation.

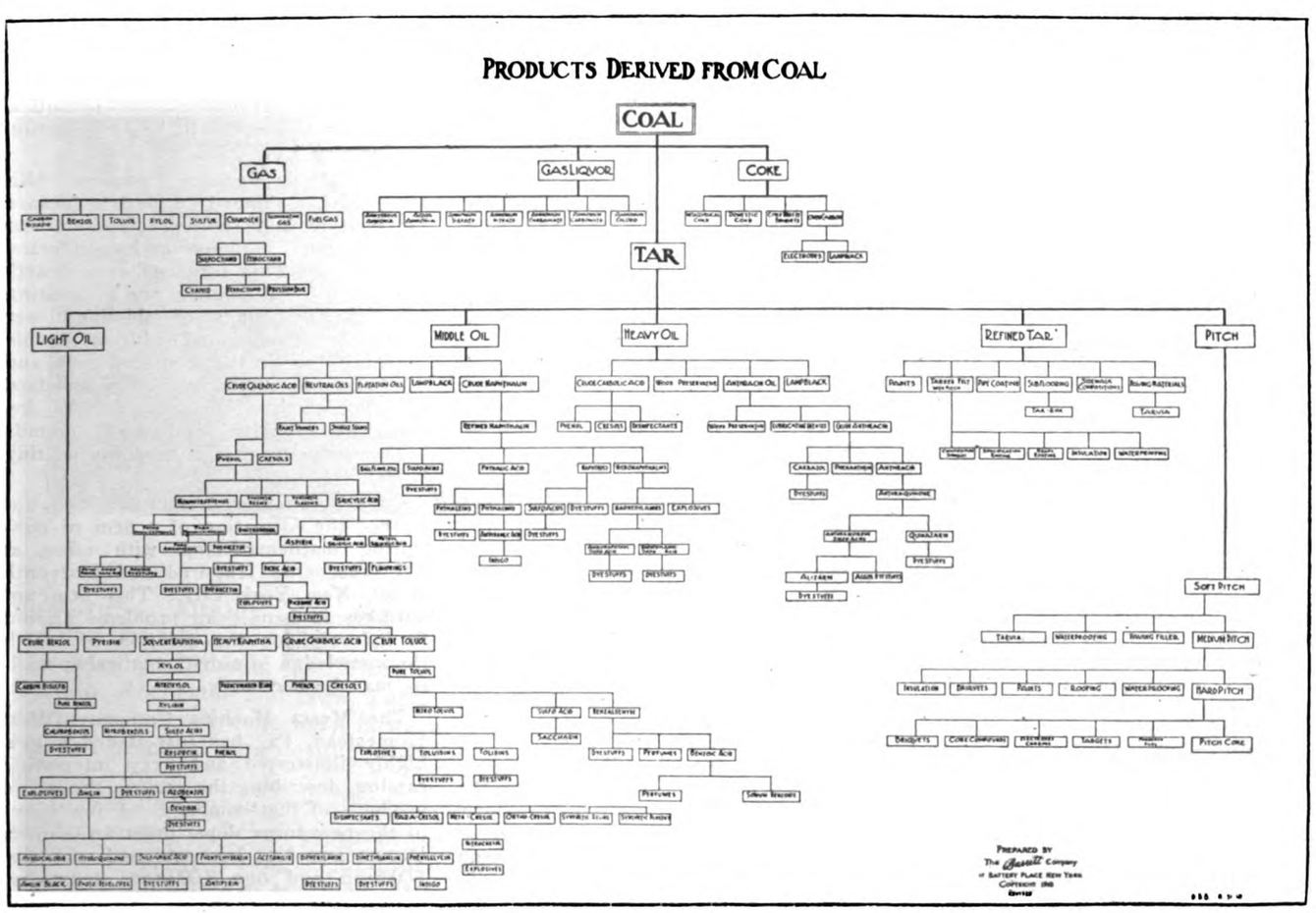
In Test No. 1, the gas for heating the retort was cut off completely after the introduction of the charge. The coke from this sample was fairly good and the charge was thoroughly coked, showing contraction in the sample box. The coke had very small and regular cell structure, but was very soft, shattering rather easily with a tendency for longitudinal fracture, but no distinct cross-fracture.

An approximate constant vapor temperature of 775 degrees C. was maintained throughout Test No. 2, which is approximately the average temperature of the vapor above the coal as reported in the test of the coke plant of the Minnesota By-Product Coke Company, St. Paul, Minn. The result in coke from this test was fair, contracted in the box and broke into large pieces with no sponge and only a small amount of fine material on the upper surface of the mass. The cell structure was small and slightly irregular but as a whole the coke was clean, soft and tougher than in test No. 1.

In Test No. 3 it was attempted to maintain an average vapor temperature above the coal of about 600 degrees C.

In Test No. 4 a temperature of about 700 degrees C. was maintained throughout the test.

In Test No. 5, a sample of Oregon coal used by the bureau in another coke oven test at Dover, O., was used an average temperature of 600 degrees C. was maintained and the results were practically identical to those secured in Tes No. 3. The complete results of these tests will appear in the publication issued by the bureau, the above being an abstract of an advance publication appearing in "Chemical and Metallurgical Engineering."



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Trade Notes

E. L. Sullivan has been appointed to represent the Green Engineering Company in the Pittsburgh district including Western Pennsylvania, Eastern Ohio and Western West Virginia. Mr. Sullivan has been a special representative for the McDonough Regulator Company for the past 10 years, six years in Chicago and four in Pittsburgh. He has devoted all of his time to special investigations pertaining to the securing of more efficient boiler and furnace operation.

The Empire Steel and Iron Company has definitely decided to rebuild their blast furnace at Oxford, N. J., and Messrs. Freyn, Brassert & Co., of Chicago, Ill., who have been retained as consulting and supervising engineers, are now preparing plans and specifications, which will include an entire new shell, new blowing engines, additional boilers and enlargement of the present stove capacity. The furnace will have a capacity of 400 tons of basic iron daily, and will be equipped with a top following the Brassert, double bell design and hopper extension, skip incline, bins, etc., also pig casting machine and all other latest improved up-to-date appliances. The majority of the iron ore used at this plant is drawn from the company's nearby mines over its own railroad, the balance coming from the Mt. Hope mines, also owned and operated by the Empire company, near Dover, N. J.

Capt. Teixeira, a member of the Brazilian military commission, who recently spent several months in this country investigating steel plants and electric furnaces particularly, has placed an order through Fenwick Freres & Co., New York, for a Greaves-Etchells electric furnace, manufactured by the Electric Furnace Construction Company, Finance Building, Philadelphia, Pa.

The American Steam Conveyor Corporation, of Chicago, announces the appointment of Morton McI. Dukehart & Co., as their representatives in Baltimore, and the surrounding territory, which includes all of Maryland, and the District of Columbia, and a few counties in Pennsylvania, Delaware, West Virginia and Virginia.

In order to care for the increasing demands for Celite products (Sil-O-Cel for heat insulation and Filter-Cel for filtration) the company has appointed Charles P. Derleth to represent their interests. Previous to his enlistment 14 months ago in the chemical warfare service, Mr. Derleth was sales representative of the J. B. Ford Company of Wyandotte, Mich. He is a graduate of the University of Illinois.

The Reading Iron Company has acquired by purchase the plant of the George B. Lessig Company, at Pottstown. This purchase was made in order to give the company a greater output of puddle bars. The Reading Iron Company has been purchasing from the Lessig company, a considerable quantity of puddle bars in the past, and by operating the plant itself, will be able to control the manufacture of its entire consumption of puddle bars, thus controlling the quality of all material entering into the manufacture of its pipe. The plant consists of two puddle mills, having a total of 22 double furnaces equipped with waste heat boilers and three two-high puddle mill trains and 22-inch three-high, three-stand rolling mill for rolling nail plate and skelp, together with the necessary heating furnaces, gas producers, etc. The nail factory contains 105 cut nail machines, together with heating furnaces, rumblers, packers, etc. The plant is complete with warehouses, machine shop, blacksmith shop, cooperage shop and carpenter shop. It is located on the Philadelphia & Reading Railroad and the Pennsylvania Railroad, and occupies about 12 acres of land. It is planned to place the puddle mill in operation as soon as possible, and it is likely that the nail factory will be put in operation at a later date. The plant is now being overhauled, and as soon as the necessary repairs are completed, the puddle mill will be put in operation.

The Electric Furnace Construction Company, Finance Building, Philadelphia, advises the receipt of an order from the Hammond Steel Company, Syracuse, N. Y., for one 3-ton furnace for the manufacture of high grade tool steels. A Greaves-Etchells furnace is also being installed for the Hong Kong Steel Foundry Company, China.

The Driver-Harris Company, Harrison, N. J., is now selling its wire rope products direct to the trade instead of through its former selling agents. These products include sash cord and tiller rope in plain iron, galvanized iron, phosphor bronze, special bronze, monel metal, and all special grades. In addition to this, the company has increased its facilities to include all grades of rope in 6x7, 6x12 and 6x19 construction, such as drilling cable, elevator rope, haulage rope, sand lines, etc., in all sizes up to ¾ inch. The other products of the company are resistance materials of nickel alloys in the form of wire, strip and sheet for electric heating controllers, rheostats and resistance elements, wire for spark plugs and weaving; rods and sheets of pure nickel and its alloys; cold rolled strip steel; nichrome castings such as annealing boxes, carbonizing boxes, pots, tubes, rotary and stationary retorts, dipping baskets, pyrometer protection tubes, etc.; flexible heater cord and thermostrip.

The Green Engineering Company has appointed the firm of Bull & Livensparger as its sales representatives in the Chicago and Northern Illinois territory. Bull & Livensparger will take charge of the Chicago sales office, 14 E. Jackson boulevard. E. H. Bull has been connected with the Greene Engineering Company as an engineer for the past seven years. D. A. Livensparger has been a member of the sales force for the past nine years.

At the annual stockholders meeting of the Aetna Foundry & Machine Co., the following directors were elected: M. W. McClane, W. M. McKee, G. P. Gillmer, V. E. Rehr.

At the directors meeting the following officers were elected: M. W. McClane, president; V. E. Rehr, vice president; G. P. Gillmer, treasurer; M. C. Boyd, secretary.

The Falcon Steel Company is erecting a new sheet mill at Niles, O., with eight stands of electrically driven rolls which is to be of the most modern type. Powdered coal will be applied to the sheet and pair furnaces as well as a slabbing furnace, two double box double chamber annealing furnaces, three galvanizing kettles and power plant boilers. A blue annealing furnace will be included in the furnace equipment. The initial installation of coal preparing apparatus will consist of a complete 5-ton coal pulverizing plant including the necessary coal crusher, elevators, crushed coal bin, Ruggles-Coles dryer and Raymond mill, together with the powdered coal hoppers, for storing powdered coal at the furnaces, powdered coal feeders, burners, etc. The pulverized coal will be transported from the milling plant through standard 4-inch wrought pipes to storage bins in the power house and throughout the mill by the Quigley compressed air system. Contract for the complete fuel equipment has been awarded the Quigley Furnace Specialties Company, of New York. It is anticipated that this mill will be in operation by January 1.

The Electric Furnace Company, Alliance, O., has shipped an electric furnace for melting and relining aluminum, to the Dayton Engineering Laboratories, Dayton, O. This furnace has a hearth capacity of 500 pounds and a melting rate of 200 pounds of aluminum per hour. It is equipped with a double charging door in the front and rear, and otherwise is similar to the standard Baily Electric Furnace of 105 kw electrical capacity, and 1,500 pounds hearth capacity, that is used for melting brass.

Dantzig, Pfeiffer & Ritt wish to announce the formation of a firm of consulting mathematicians, with office at 509 West One Hundred and Sixteenth street, New York City. This firm undertakes to handle all problems arising in industry for the solution of which the knowledge of a mathematical specialist may be necessary.

The Mesta Machine Company, West Homestead, Pa., has just issued a new highly illustrated and very interesting catalog, describing the various shops and products of that company. A few views of the new forge department are shown. Department No. 3 is equipped with one 1,000-ton and one 2,000-ton steam hydraulic forging press.

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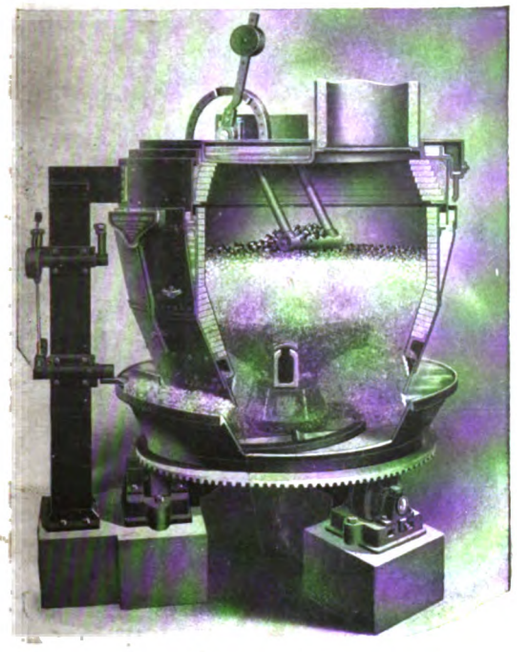
The Blast Furnace and Steel Plant

Pittsburgh, September, 1919.



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